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ABSTRACT

This handbook for teachers of the primary grades suggests a variety of means by which children can be provided with experiences related to science and mathematics. Chapters are devoted to the classroom garden, the classroom zoo, the classroom museum, objects children bring to school, and field trips. Each chapter describes preparations to be made and suggests procedures to be used throughout the school year. The various plants, animals, or objects which might be included are described, and their care is discussed. Field trip discussions suggest places to visit (e.g., a tree, a barn, the school yard), and questions that might be asked at each location. A bibliography related to the topics discussed is provided. The first part of the bibliography presents an annotated list of materials for the teacher; the second part provides lists of children's books. Although this handbook was prepared for use by teachers using the MINNEMAST materials, it can be used independently of the other materials. (SD)

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LIVING THINGS IN FIELD AND CLASSROOM

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Do p 257

This edition of
Living Things in Field and Classroom
is dedicated
by the Minnemast staff
to the memory of
ZACHARIAH SUBARSKY
whose wit and wisdom can be seen
in these pages, as in all his work.

LIVING THINGS IN FIELD AND CLASSROOM

A MINNEMAST HANDBOOK FOR TEACHERS
OF EARLY ELEMENTARY GRADES

By

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MINNESOTA MATHEMATICS AND SCIENCE TEACHING PROJECT

This second edition of Living Things in Field and Classroom is based on the 1967 edition, which was designed to serve as a supplement to the MINNEMAST curriculum units, and to insure that living things might be available in the classroom when called for in the curriculum.

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Science Teaching Project
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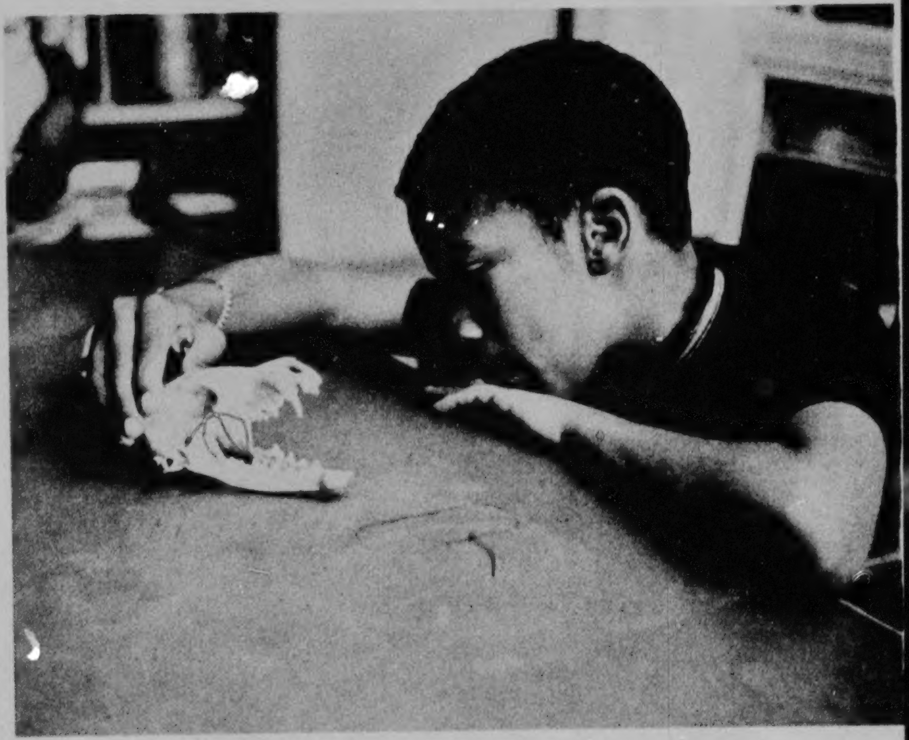
INTRODUCTION

Young children are curious by nature. They are especially intrigued by living things. If they are given direct, firsthand experiences with plants and animals in the early grades, their curiosity will be nurtured and enhanced, and they will come to more advanced learning activities with a background of pleasant and instructive experiences.

So that you may best provide these experiences, we have prepared this handbook to help you maintain living things in your classroom, and to help you coordinate outdoor teaching with your indoor curriculum.

You will find much more material in the following pages than you can possibly use during a single school year. Select those activities that suit your needs and are practical within the limitations of your classroom and community. It is not the number of specimens in your classroom that is important. It is the educational use to which they are put that counts.



PREVIEW OF THE HANDBOOK

Browse through the handbook to get a sense of what is in it, how it is organized, and the ways in which it can help you.

At the beginnings of Sections 1 and 2 you will find information about classroom gardens and zoos that you should read at the very beginning of the school year, because there are projects you may want to start at once. Each of these sections gives practical suggestions for keeping living things in the classroom – what kinds of organisms are suitable, and how they can be kept alive.

Section 3 offers help for those unexpected moments when children bring things in – moments that could lead to exciting learning experiences or to missed opportunities, depending on how you exploit the situation. You will find suggestions for initial discussion and activities, and guides to detailed examination and identification of the specimens, together with suggestions about what to do with them afterwards.

Some of the things children bring in may find their way into the classroom museum. Section 4 suggests how to make the museum more than a shelf full of dusty, ill-assorted objects. We outline a technique for organizing exhibits around common properties or other significant relationships among objects.

Section 5 is a guide to field trips. It tells how they may be used to coordinate the out-of-doors with classroom teaching, and how to motivate, organize and follow up field trips. We include many illustrated suggestions of convenient places in which you and the children can explore living things.

Our Bibliography includes children's reference books and story books, as well as teachers' reference material. Living things themselves should always be the prime source for learning. The children should be encouraged to examine, explore and speculate to their hearts' content before they are referred to books for further information. But at the right time, reference books play an important part in learning about living things.

IMPORTANCE OF WORK WITH LIVING THINGS

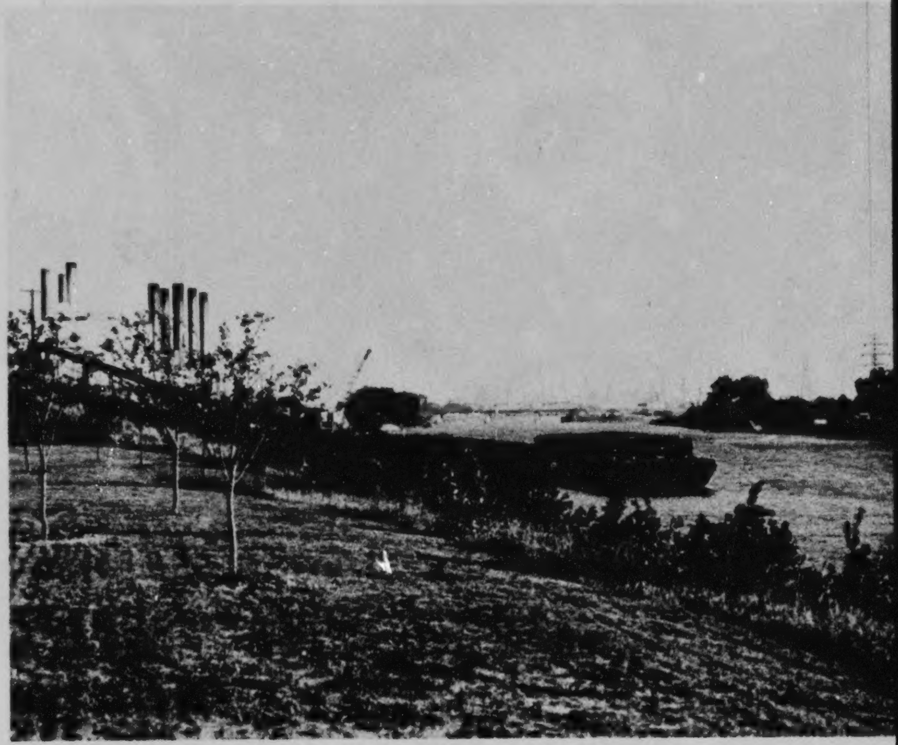
The routine care of plants and animals in the classroom can help develop sensitivity and respect for life. Pleasant experiences in the study of living things can lead to a permanent interest in life science and lay the foundation for the development of an ecological point of view, which is basic to the solution of many environmental problems of our time.

AN ECOLOGICAL POINT OF VIEW

How an animal or plant manages to stay alive as a species in nature is explainable in terms of how it is adapted to the physical conditions in its environment (wet, moist or dry; dark or light; warm or cold, etc.) and how it is adapted to the other organisms, harmful or beneficial, that share its environment. The science that studies these relationships is called ecology.

An ecosystem is made up of all the living things in a community, together with their physical environment. In the ecosystem the organisms are in constant interaction with each other and with the physical environment. Man is an important member of the ecological community. Not only does he have the normal effect of any other living thing, but some of man's technological developments upset nature's balance.

As a city reaches into a wild area, or as highways cut through a countryside, certain animals and plants disappear. Others, such as cockroaches, rats, dogs and cats, increase in numbers. Bodies of water such as rivers and lakes become polluted by industrial and human waste, causing the death of native fish and shorebirds. The air over cities becomes contaminated by smoke from household incinerators and from factories, and by automobile exhaust. (See Bibliography, p. 121.)



YOU, THE TEACHER

You are in a position to start a chain of experiences for your children that can lead them to the increased awareness and the special knowledge that are prerequisites for intelligent action with respect to many of our environmental problems.

For example, suppose your class sees a robin pulling a worm out of the soil. Questions like these will help develop an ecological point of view: How many worms are in the ground? How many worms does a robin eat each day? Suppose there were just enough worms in the soil to feed all the robins; what would happen if more robins moved into the area?

Suppose your class visits a construction site. You might discuss ecological questions such as what plants and animals lived there before construction began and what has happened to them since.

In maintaining living things in the classroom, you can call attention to those conditions under which they thrive and those under which they perish.

You will find many similar situations to help in the development of an ecological point of view, so indispensable in today's world. We hope that this handbook will help you guide the children in this direction, or in one of the many other important directions that an interest in natural science can take a child.

YOUR CLASSROOM GARDEN

SECTION 1

A classroom garden can be a beautiful, interesting and useful part of your room. Because it should be a working garden, do not expect it to look like a professional florist's display, and do not strive for permanence. Discard old, unattractive or useless plants and replace them. Encourage the children to help you in the planning and daily care of your garden.

The materials and procedures in this section have been tried under conditions as difficult as those in the average classroom, if not worse, so the chances are that you will be successful with them. On the other hand, conditions in your classroom are different from those anywhere else, and you may succeed with things that would not work for another. So do not hesitate to improvise and experiment.

ANTICIPATING THE SCHOOL YEAR

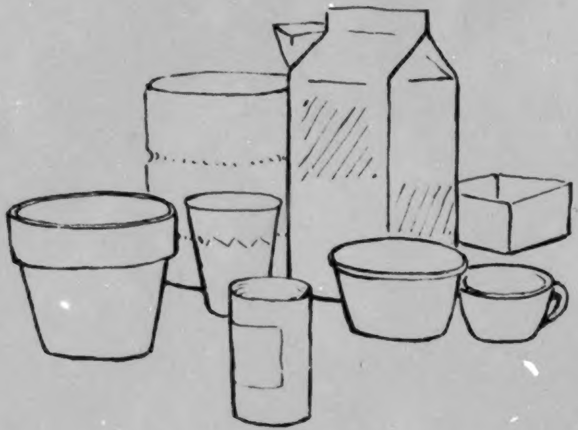
Before the year begins, examine your classroom to decide on appropriate places for plants. Buy seeds from local stores. Get the soil, fertilizers, insecticides or other materials you may need. (See the following pages.) Locate a source for potted plants. (Greenhouses frequently sell off their summer stock as fast as possible, so you may not be able to find the plants you want if you delay too long.) If you have access to a garden, take slips for rooting. (See p. 7.) It is helpful to keep a record of your successes and failures to guide you next year.

OBTAINING MATERIALS

You can get most things you need for a classroom garden from your supermarket, variety store, or local greenhouse.

POTS

Any container that can have a hole punched in the bottom for drainage can serve as a pot. You may use milk cartons, tin cans, frozen food containers, or the more conventional plastic or clay flowerpots. Flowerpots come in many sizes and can be purchased in greenhouses, but many people have spares to give away. For short-term use, paper cups are satisfactory. (Cups for hot drinks are more substantial than thin waxed paper cups.) For germinating seeds, you can even use the molded sections of egg cartons.



SOIL

The easiest way to get soil for your classroom garden is to buy the sterilized balanced soil sold in plastic bags. The best soil for potted plants is a mixture of one-third soil, one-third peat moss and one-third sand. These materials can be obtained from supermarkets.

Soil dug from a garden or yard can be used, but it is often contaminated with organisms that cause plant disease. It may also be unsuitable in mineral content or degree of acidity.

POTTED PLANTS

Supermarkets and variety stores usually carry hardy house plants and seasonal plants such as crocus, lily and poinsettia. Greenhouses should be able to provide a more interesting variety of plants, especially early in the fall and late in the spring. (See p. 10 for recommended plants.)

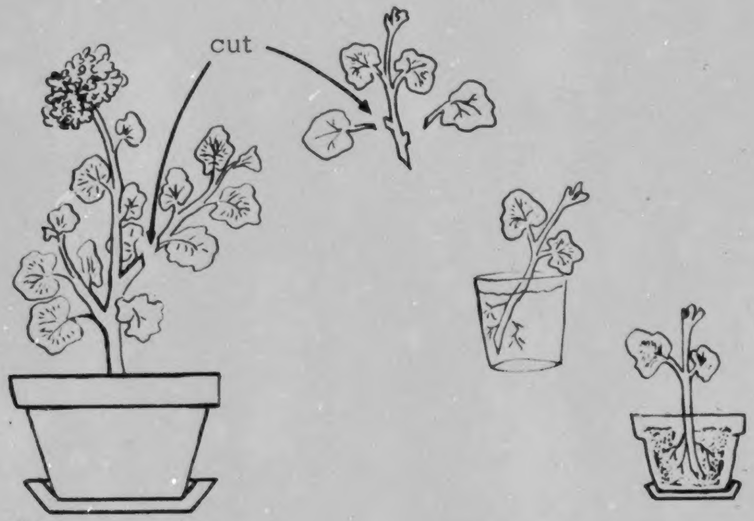
SETTING UP THE GARDEN

You may want to start some plants at the very beginning of the school year. Others will be appropriate to start as you go along. (See p. 17 for ways in which you can use your garden in teaching.)

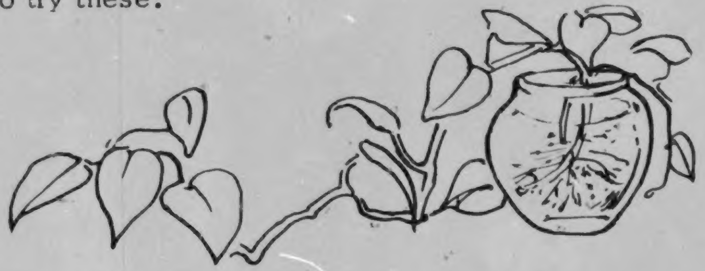
Don't worry about failures, and don't feel you have to keep all the plants you start with. Some will be more permanent, others should be discarded or sent home with the children as soon as their classroom usefulness is over.

PREPARING CUTTINGS

To make cuttings of such plants as geranium and begonia, select sturdy stem-ends three to four inches long. Remove any flowers. Cut the stem on a slant just below a leaf. Remove this leaf and the next one above it. Allow the cut ends to dry for about half an hour to permit a callus to form, and then place the two lowest leaf nodes under water or in moist sand. If you are rooting the cuttings in sand, a plastic bag placed loosely over a single cutting or a sheet of plastic over a tray of them will protect the cuttings from excessive water loss.



Take more cuttings than you need, for some may not root. Cuttings taken late in the season after the nights have turned cool may not root as well as those taken earlier in the summer. Florists sell chemicals which aid root growth, and you might like to try these.

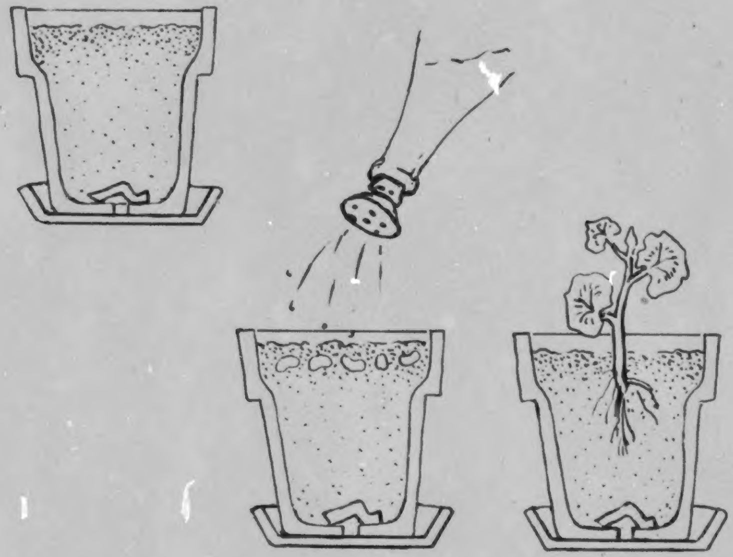


GROWING PLANTS IN WATER

Many plants can be grown without soil. Cuttings of ivy, philodendron and Wandering Jew will root and grow indefinitely in water if given some plant food every few weeks. Cuttings such as coleus and begonia can be rooted in water and then planted in pots. (See p. 33 for water plants to put in aquaria.)

PREPARATION OF POTS

All types of pots are prepared in the same way. Re-used pots should be scrubbed with a brush in hot water. Food containers should be rinsed thoroughly. Water must be able to drain, so be sure there is a hole in the bottom of the container. Cover the hole with a small stone or piece of flower pot to keep the soil from falling through. Over this add soil and water. (It is easier to plant in moist soil.) You should set the pots in saucers or pans to collect the excess water that drains out.



PLANTING

Transplanting from the Garden

If you pot plants from the garden, spray them well with an all-purpose plant insecticide before you bring them into the classroom. Use a trowel to dig up the plant together with some soil, so as to disturb the roots as little as possible. Place in a pot with a layer of soil over the bottom, hold the plant upright, and add soil to fill in around the sides. The soil level in the pot should be the same as the ground level when the plant was in the garden. Keep the plant well watered and out of direct sunlight for a few days.

Potting Cuttings

If you have rooted a cutting in sand, it is ready to pot when the cutting seems firmly attached to the sand. Use a small pot, two and one-half or three inches in diameter. Use a spoon to scoop up the plant, together with some sand, without disturbing the roots. Set the plant into the pot, which you have partially filled with soil, and add more soil to about one-half inch from the top of the pot.

If you have rooted the cutting in water, it is ready to pot when the roots are an inch long. Put a layer of soil in the bottom of a small pot. Insert the plant and hold it in position with one hand while with the other hand you gradually add soil with a spoon or trowel so that it sifts around the roots. When the pot is half full, water it to insure good contact between the roots and the soil. Add the rest of the soil and press it down firmly.

You may cover newly potted cuttings with plastic bags for a few days to conserve moisture until the roots are firmly established. Then the bags can be removed and the plants can be put in the sun.

Transplanting to Larger Pots

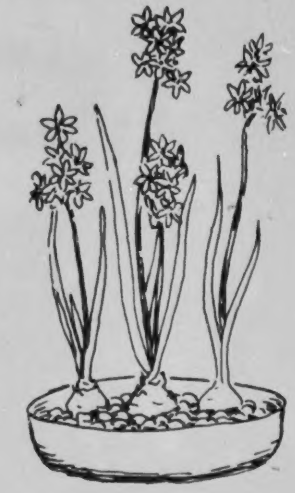
Plants should not be put in larger pots until they have outgrown the small ones.

To transplant to the next larger size pot, prepare the new pot in the usual way. Put a layer of soil over the bottom. Take your small pot with the plant in it, and hold it upside down with the plant passing between your fingers. Rap the pot sharply to loosen the soil. It should drop into your hand in one chunk. Remove the pot, and carefully turn the plant right side up, place it in the new pot, and fill in the empty space at the sides with more soil and water. You want to disturb the roots as little as possible in this operation.

GROWING BULBS

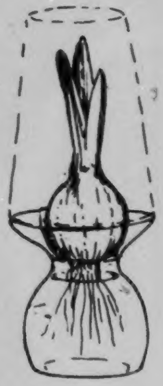
Greenhouses, variety stores and department stores carry large supplies of bulbs in the fall. Mail order seed and nursery companies can usually supply bulbs at any time of the year, although they have their largest selection during the fall planting season.

Paper-white narcissus is the only bulb that is easy to obtain and that will grow and bloom in water and pebbles without a preliminary growth period in the dark, though it does better when started in the dark.



Place an irregular layer of stones or gravel in a pan or bowl two or more inches deep. Arrange the bulbs so they are supported by the stones but not completely buried under them. The bulbs should not touch each other. Add water until it touches the bottom of the bulbs, and keep it at this level.

Narcissus flower parts are small but regular, and if you use a small paint brush to transfer some pollen to the pistil, seeds should be produced.



The hyacinth is spectacular, but it will not produce good flowers without a period of several weeks in a dark, cool place. You may want to try growing some if you have a dark, cool cupboard. The hyacinth will grow in soil or over water. There is a special hyacinth glass that supports the bulb over but not touching the water. (The roots grow down to the water.) Cover the top of the hyacinth bulb with a paper cup and place it in a cupboard. If you use soil, keep it moist but not flooded. When the roots are well developed, the tips of the leaves reach the bottom of the inverted cup, and the flower bud is visible, the plant should be brought into the light.

An amaryllis bulb will send up a flower stalk a month or six weeks after it is planted in soil. It does not need to be kept in the dark. The leaves may not come up until after the flower has bloomed. This is the only bulb commonly grown indoors that can be successfully saved for a second blooming.

The flowers are spectacular and large enough for the children to see all the flower parts and to demonstrate pollination by putting pollen from the large stamens on the sticky central pistil.

PLANTING SEEDS

Greenhouses, groceries, variety stores and hardware stores carry large assortments of garden seeds in spring and summer. Seed companies and biological supply houses have seeds available all through the year. It is helpful to have catalogues from seed companies in the classroom, for they are very informative and well illustrated. (See Bibliography, p. 116, for list.)

Commercial seeds are guaranteed to germinate and have been treated for protection against fungus diseases. You can try planting beans that you get from grocery shelves, but they may not sprout if they are too old or have been treated to prevent spoilage. Test a few before you pass them out to the children.

When you plant seeds, fill a pot or tray with moist soil to about one-half inch from the top. Arrange the seeds on the surface, then cover them with a layer of soil about the same thickness as the seed. Press the soil down firmly and sprinkle with additional water. Keep the soil moist. It is helpful to cover the top of the container with glass or plastic until the seeds sprout. (Always leave a small opening to prevent molding.) Keep the seeds out of direct sunlight until the young plants come up. Seeds will germinate in moist sand or on moist cloth or paper, but they must be transplanted to soil if well-developed plants are desired. (See p. 8.)

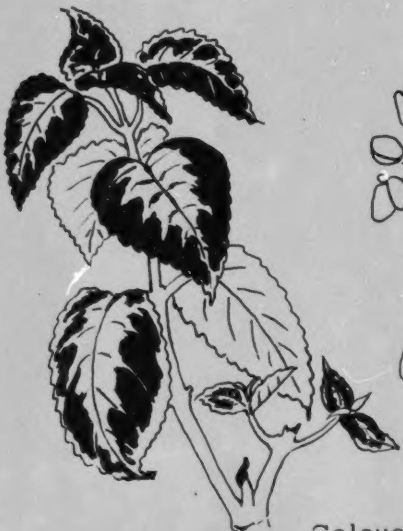
RAISING FLOWERS FROM SEED

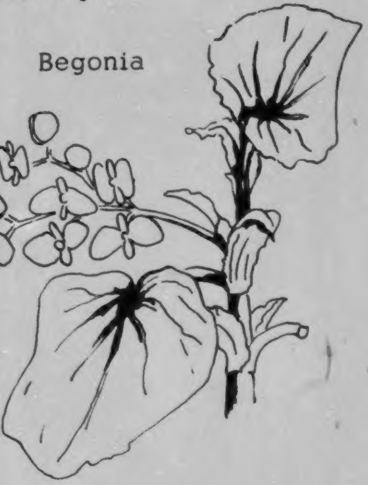
There are not very many plants that can be grown from seed and brought to bloom in the classroom in a comparatively short time. Dwarf marigolds and dwarf zinnias will bloom within three months of their planting if given adequate light. Scarlet runner beans should be tried, for they show spectacular growth and sometimes bloom, producing beautiful red-orange flowers. The flowers tend to abort, however, and don't produce seeds. Morning glories, wax beans, cucumbers and Tiny Tim tomatoes should also bloom in the classroom. (See pp. 21 and 22.) Also see Coleus, p. 11.

OTHER RECOMMENDED PLANTS

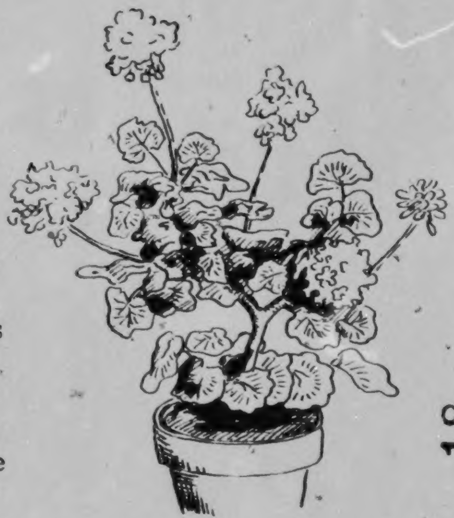
There are not many plants which fulfill the classroom requirements of being easy to obtain, useful for class projects, and resistant to disease, insects and extremes of heat and cold — that is, plants that are next-to-indestructible. The ones listed below are the most likely candidates.

Begonias, the fibrous-rooted types, will bloom almost anywhere and will root readily in water, in sand or in a terrarium. Select the kinds that greenhouses recommend for summer planting in shady spots. Some varieties bloom more readily than others. Avoid varieties with white flowers, since some of these are susceptible to mildew. Begonia cuttings are excellent terrarium plants.


Coleus

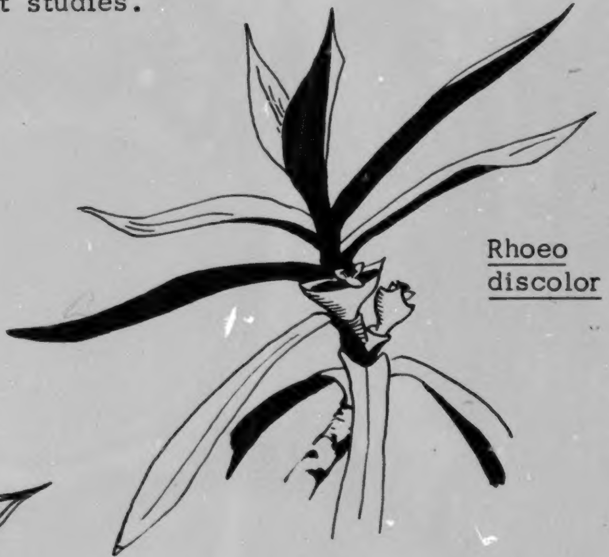

Begonia

Coleus is easy to root in water or sand. Its leaves are beautifully variegated, and in the short days of winter the plant may put up spikes of tiny flowers, which produce seeds that will germinate a few days after ripening. Coleus is susceptible to mealy bug infestation, especially if brought in from a garden, but this is easily controlled. (See p. 16.) The distinctive square stem is common to all mints. The opposite pairing of leaves and their color patterns can be used for symmetry and art projects. The semi-transparent stem and high water-loss rate (transpiration) make coleus useful in experiments demonstrating the movement of colored water in stems.

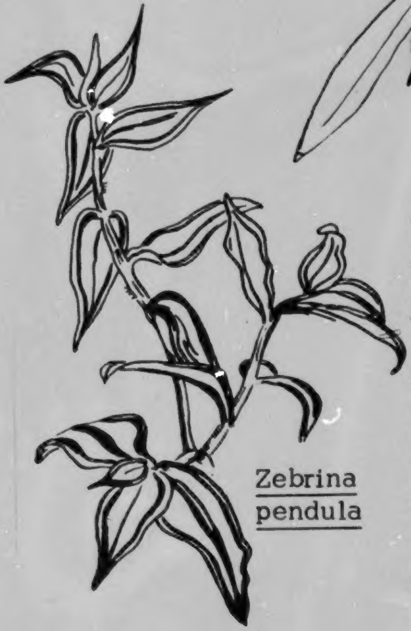


Geranium**s** tolerate low humidity and great temperature fluctuations. They will bloom if given enough light (several hours of sunlight daily). It is better to start with well-rooted cuttings or new plants, but repotted summer plants can be used, if cut back. Slips are slow to root. You will find that the more commonplace and less exotic varieties are more likely to do well under poor conditions. This is true for most plants and is the reason old-fashioned varieties are still popular. Geraniums are especially useful for giving young children experience in observing properties. The leaves are hairy to touch and have a pleasant characteristic odor when crushed.

Impatiens (Sultana) is easily available, and has transparent stems useful for dye experiments. It will bloom under poor light conditions, but it has a tendency to drop its leaves and is not as resistant to environmental fluctuations as some other plants. However, some teachers are quite successful with it. Avoid exotic varieties such as plants with double flowers or tangerine colors. This plant is a good substitute for coleus in rooting and water transport studies.

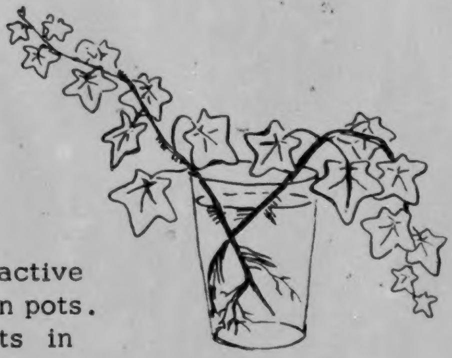


Rhoeo discolor



Zebrina pendula

Tradescantia in two varieties is illustrated here. One is a potted plant, Rhoeo discolor, commonly called Moses-in-a-boat, which produces interesting white flowers in large boat-shaped bracts. The leaves have beautiful purple undersides. The other is a relative, Zebrina pendula, commonly called Wandering Jew. It is a vine with green and white, green and purple or all-green leaves. This plant roots rapidly in water, and it can continue to grow there or it can be potted.



Ivy is always attractive either in water or in pots. (For growing plants in water see p. 7.)

Other potted plants, such as philodendrons, peperomias, succulents and cacti, and festival plants such as poinsettias and Easter lilies, are nice to have around for their decorative effect, their usefulness in art activities, and their general interest.

THE TERRARIUM

A terrarium is a covered transparent container planted with a miniature community of plants. It needs little attention and is quite easy to make. Several small ones may be more useful than one large one. Children enjoy making their own terraria in plastic boxes or peanut butter jars. Three types of terraria are described here.

In order to make any terrarium you will need:

1. A glass or plastic container. (Anything from a peanut butter jar to a large aquarium will do. A plastic shoe box is especially handy.) Your container should be deep enough to allow some headroom for the plants to grow in.

2. A removable transparent cover. (Glass or plastic wrap will do.)

3. Drainage material, such as sand or gravel.

4. Soil.

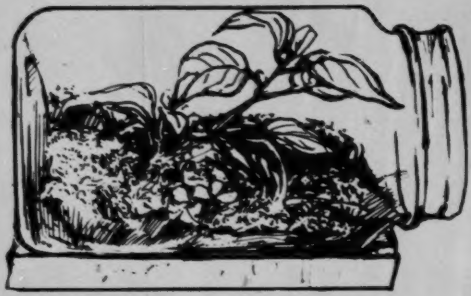
5. Plants and seeds.

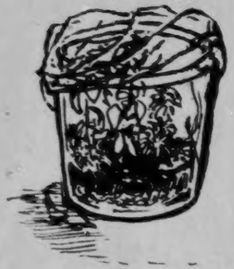
MOIST WOODLAND TERRARIUM

This is probably the most useful kind for keeping small plants such as ferns, mosses and fungi, and for rooting cuttings.

Put a half-inch layer of sand or gravel or a mixture of both in the bottom of your container for drainage. Add one inch of moist soil. This should preferably be in the proportions of one-third soil, one-third sand and one-third peat moss or humus, but ordinary garden or potting soil will do. (The soil should be moist enough to cling together in balls when pressed in the hand.)

Make holes in the soil, gently insert the roots of the plants, and press the soil around them. A carpet of moss around the plant keeps the soil from spattering. Sprinkle carefully with water and cover almost all the way with glass or plastic.





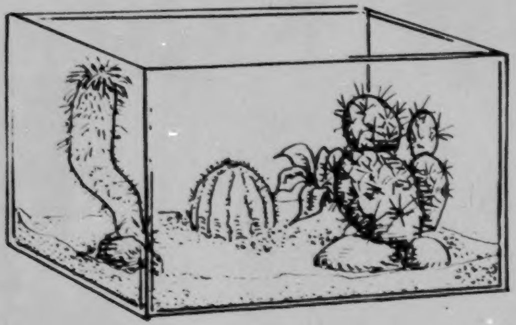
Adjust the lid so that a little but not much moisture collects on it. Water only when the soil appears dry, once a week or less. Unless the lid is open, keep the terrarium out of direct sunlight because it will overheat.

Appropriate plants for a woodland terrarium are mosses and shelf fungi, ferns, small house plants or cuttings of ivy, begonia, coleus, or tradescantia, or seeds of different kinds. As plants get too large, prune them or replace them. If you can get woodland soil and moss in your terrarium, watch for surprises as old woodland plants die and new ones appear.

In early spring plant a terrarium with any young plants that are just beginning to appear. Their rapid growth in the warm room will be spectacular. Young violet plants, wild ginger, emerging scillas, small weeds or moss and young seedlings can be used. It is also interesting to place a piece of old log or a spadeful of garden soil in a terrarium and water it. In a few days you will have an interesting assortment of young plants and small animals. Encourage the children to study them with magnifiers.

DESERT TERRARIUM

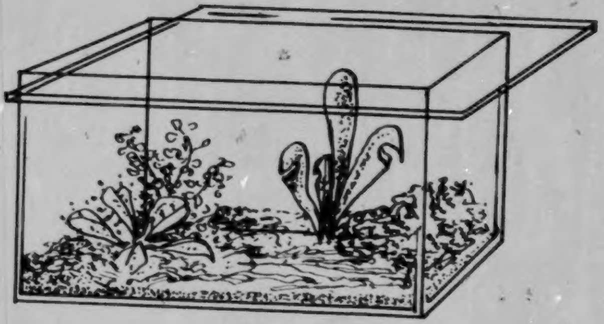
This kind is easier to keep than a woodland terrarium, but not as much happens in it. Use moist soil mixed with an equal part of sand over the drainage layer. Small cacti and some succulents such as jade plants, hens and chicks, and aloe will grow under these conditions. (Handle the cacti with tweezers or gloves.) After the plants are in place the soil should be kept evenly moist until the roots are established, but never add so much water that you can see any standing in little pools. From then on water sparingly, perhaps once a week, so that the surface of the soil remains fairly dry. Keep in a sunny spot and do not add a lid. A wire screen can be put over the top if an animal (such as a horned toad) is to be housed in the desert terrarium.



BOG TERRARIUM

The bog terrarium is especially interesting because insect-eating plants can be grown in it. Put in the drainage layer, then a layer of sphagnum moss. No soil is necessary. Order materials and plants for a bog terrarium from a biological supply house, unless you are near a natural bog. Keep it cool, covered almost all the way, and well lighted. Keep the gravel layer under water all the time.

There are many modifications of terraria. Large woodland ones can be made with a sloped drainage layer and a bog or shallow pool at one end. They present many opportunities for artistic creativity in addition to their biological uses.



KEEPING YOUR PLANTS HEALTHY

To grow well, plants require proper amounts of moisture, light and heat. Plants also require proper nutrition and protection from insects and disease.

MOISTURE

All plants need water; they require moisture in the air as well as at their roots. But the moisture in the air of heated schoolrooms is about equivalent to that of a desert. There are several ways of dealing with this problem.

Potted plants can be set on stones or gravel in leakproof containers. (Fiberglass window boxes are excellent for this purpose, but any large pan will do.) The layer of stones should be kept flooded to increase the humidity around the plants. The plants can be watered either by pouring enough water into the pan of gravel or stones so that the water can rise through the openings in the bottoms of the pots, or by pouring water into the pots from above, allowing excess water to drain out into the supporting layer of stones. Before holidays and weekends, add extra water to the pans.

Water the plants whenever the soil in the pots appears dry, but do not water so frequently that the soil is always moist. It is important to let the soil dry out between waterings, because over-watering will lead to the decay of the underground plant parts. If this has happened, the plants will look wilted even though the soil is moist. In this case, let the soil dry out before watering again. If the plant is not able to restore its root system, take cuttings from it to try again, and throw the rest of the plant out.

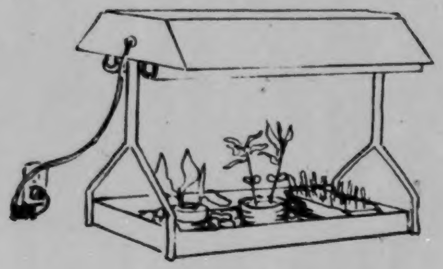
Cold, chlorinated tap water is not recommended. If you do use tap water, try to have it at room temperature. Ideally, you should keep a container of water standing several days to warm it and free it from chlorine before you use it for watering your plants.

Small delicate plants that need a moist environment grow well in a terrarium, where the humidity can be controlled. (See p. 13.) Cuttings and slips can also be rooted in a terrarium.

LIGHT

Some plants can survive in very poor light. These grow slowly and seldom bloom. Most plants need several hours of bright light from a window (preferably facing south, east or west) or additional artificial light in order to grow well and bloom. Seedlings and young plants need considerable light to keep them from becoming pale and spindly.

A sunny windowsill is the most appropriate place for plants in the classroom. If the natural light is poor, as in rooms facing north or in rooms where plants cannot be close to a window, an additional light source on a table will be very helpful. Small fluorescent fixtures can be bought from seed companies



or biological supply houses, or can be made by anyone handy with tools. Such fixtures can be equipped with timers that turn them on and off automatically to give a controlled amount of light.

If your windows with the best light have heating units under them, see the following paragraphs.

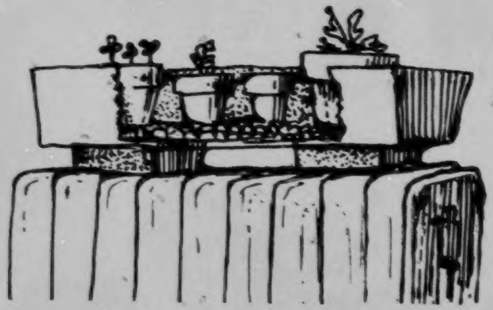
TEMPERATURE

How to keep plants from being frozen or cooked is a constant classroom problem. Winter classroom temperatures are by no means ideal for plant growth. However, some plants will survive fluctuations in temperature on weekends and holidays if you take a few precautions.

If you expect very cold weather over holidays, either place cardboard or newspapers between the plants and the windows, or move the plants into a warmer part of the room. Temperatures are unlikely to reach freezing, since the plumbing must be protected.

If you want to keep your plants at windows that have heating units under them, raise the plant trays on blocks or bricks so that air can circulate beneath them. This will reduce excessive temperature fluctuation while allowing you to take advantage of the light.

If worst comes to worst and disaster does strike, remember that plants are expendable and can be replaced.



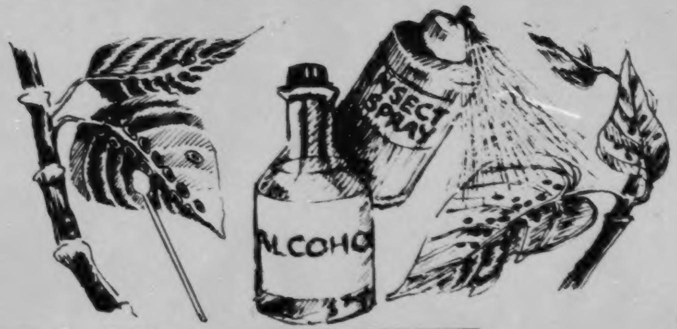
PLANT FOOD

The natural plant nutrients found in good soil are gradually depleted in a pot. All plants should be fertilized periodically. Solutions of essential minerals are sold in bottles in stores that carry gardening supplies. Ordinarily, small amounts of the solution are added every few weeks to the water used in watering the plants. Directions for use are supplied on the containers.

PEST CONTROL

If aphids, scale, or mealy bugs appear, the plants will need some treatment. Aphids (plant lice) cluster on growing tips of stems. Scale insects appear as flat brown oval disks on stems or near the veins of leaves, especially on the undersurface of the leaves. Mealy bugs appear in white, cottony clumps around growing tips and at the base of young leaves.

Scale and mealy bugs can be removed with cotton-tipped toothpicks dipped in rubbing alcohol or witch hazel. Plants with aphids should be sprayed with an all-purpose plant insecticide. Several kinds are carried in stores which supply other materials for gardening. If the plants have too many insects, discard the plants to protect your healthy ones from infestation. A weekly rinsing of the leaves will be very helpful in discouraging insects and will improve the appearance of the plants. Hold plants under faucet or spray and rinse both sides of leaves.



USING YOUR CLASSROOM GARDEN

Specific uses of plants for teaching are suggested below, but general daily care is also important. Daily care can bring out the facts that plants grow (measure them and record the measurements), bend toward the light (keep turning them each day), and need water regularly.

PLANT STRUCTURES

Let the children examine whole plants, roots included, by uprooting and washing the soil away from a plant that is to be discarded. To gain some appreciation of the extent of the root system produced by a plant, have the children carefully remove and untangle all roots, lay them end to end, and measure the distance they stretch.

Supermarkets offer a great variety of plant materials that are useful for classroom activities. There are seeds to grow, fruits to dissect, vegetables and flowers to examine. Whole vegetables are seldom seen by many children brought up on frozen or canned food. Use unshelled peas and green beans to show fruit structure and seed arrangement. Discuss the uses of the structures you see (the pod, the seeds, the attachment points of the seeds). Cut cross-sections of cucumbers, peppers, tomatoes, apples and oranges to see the structures. Count the seeds in a single orange, plant them and find out how many orange trees you could get. Count the seeds in your Halloween pumpkin, dry them and use them in germination experiments.

Take apart, leaf by leaf, a head of lettuce, a brussels sprout, a cabbage or a bunch of celery. Note color difference between inside and outside leaves. Look for small buds at the base of each separated part. Try counting the leaves on a brussels sprout.

Much of a plant is water. You can demonstrate this by measuring water loss. Weigh individual fruits, vegetables or leaves. Allow them to dry out, weighing at intervals (daily or less frequently, depending on the rate of loss). Compare water loss under varied conditions (on a radiator, on an open shelf, in a plastic bag).

SEED PARTS

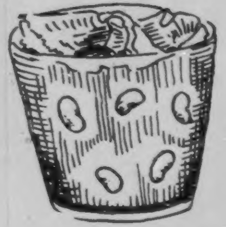
Large seeds, such as beans, corn kernels and pumpkin seeds, are good for demonstrating seed structure and embryo plant parts, and for experiments with seedlings. Pumpkin seeds can often be taken directly from the Halloween pumpkin and germinated. Lima and wax beans are useful for showing seed parts (seed coat, stored food, young plant). Soak them overnight before taking them apart.

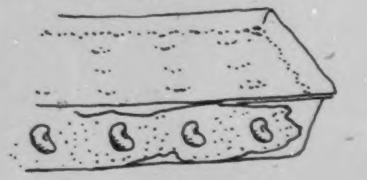
As large seeds germinate, the parts of the young plant are easy to identify. The bean halves are called cotyledons. They can be observed to shrink as the young plants develop. Try removing one or both cotyledons from a young plant, and compare this plant after a few days with one that still has its cotyledons.

GERMINATION

Only a few kinds of seeds germinate rapidly under ordinary conditions. The seeds listed above should germinate within two days to a week. Overnight soaking of large seeds will speed germination.

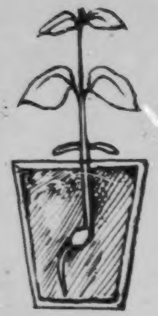
Seeds can be germinated in sand, in soil, or between layers of moist blotters or paper towelling. You can also line a tumbler or glass jar with a blotter or towelling and place seeds between the glass and the paper. Crumple more towelling to fill the center of the glass and put a little water in the bottom of the container. An index card placed over the top will reduce evaporation. Start enough seeds so that the children can take apart and examine the seeds at various stages of germination.

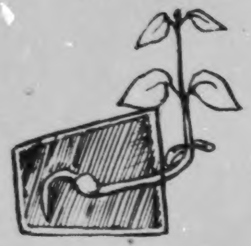




PLANT GROWTH

Germinate seeds between blotting paper and glass to show the effects of gravity on plant growth. The roots will grow down and the stem will grow up regardless of the position of the seed. If the glass is tilted, the seedling will adjust its growth so that the roots keep growing down and the stem keeps growing up.



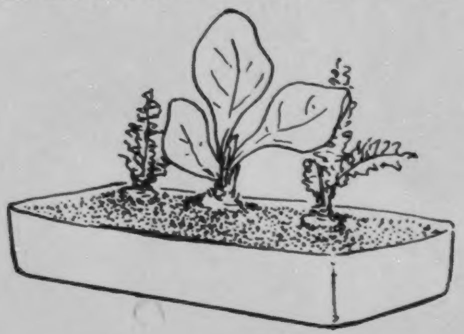


Small seeds such as radish and grass seeds produce seedlings that are small but respond rapidly to environmental changes in light, temperature, moisture and gravity. Young radish seedlings respond to change in light direction in only an hour or so. If the plants are leaning toward the window in the morning, turn the pot around, and long before the end of the day the children will be able to see that the seedlings are again leaning toward the light. Such seedlings wilt and recover rapidly from loss of water. They lose their green color after a few days in the dark and regain it after a day or two in the light.

When you take cuttings, the effect on the parent plants will be interesting to watch. Growth of plants can be modified by pinching out the terminal buds on the shoots to allow the side buds to develop.

Plant the tops of carrots, beets and radishes in moist sand to get a new growth of leaves.

Grow an onion in a glass over water that just touches the bottom of the bulb. The roots will grow very rapidly. The leaves are especially interesting because they are tubular.



Plant growth is affected by crowded conditions. Take two pots of the same size and plant one with twice as many seeds as the other. Note the differences between the growth of the plants in the two pots as the plants get bigger and bigger.

PROPAGATION

Many methods of plant propagation can be demonstrated in the classroom.

Cuttings

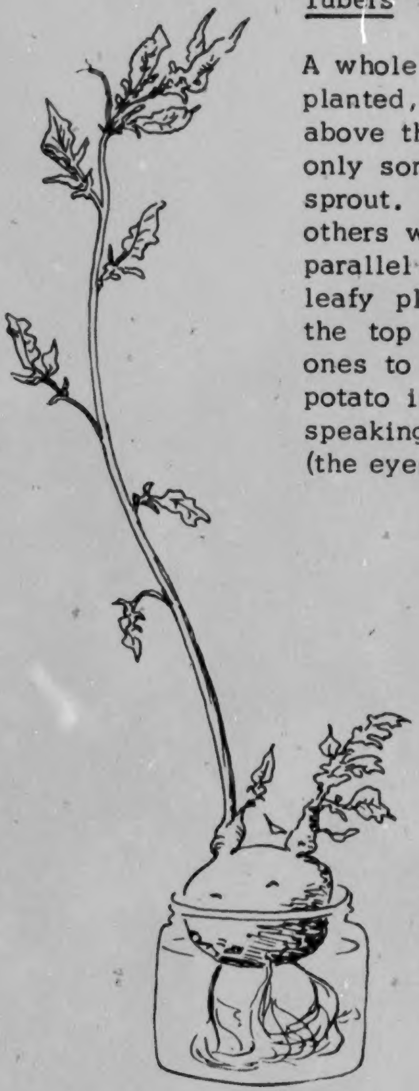
Cuttings taken from classroom plants can be rooted in water or sand. Rooted cuttings are excellent for children to plant in paper cups to take home and watch. Show the children how to transplant to larger pots. (See p. 7 and 8.)

Seeds

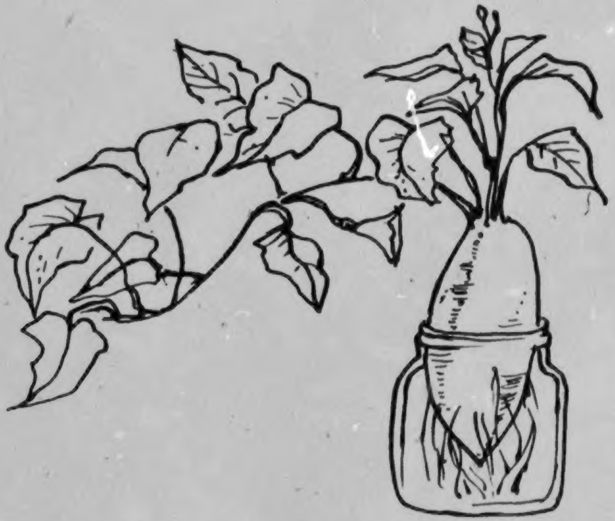
See Germination, (p. 18), and Life Cycles (p. 21), for propagation by seed. To demonstrate fertilization, try to find a potted lily or potted tulips with stamens that have not been removed. (If you can't find them, get some with buds and wait for them to open.) The children can put pollen on the sticky central pistil and observe how, while the flower dries up, the central ovary enlarges as many young seeds develop in it. Also see Narcissus and Amaryllis, p. 9.

Tubers

A whole white potato can be planted, with a portion of it above the soil. Observe how only some of the eyes (buds) sprout. If these are removed, others will sprout. This is parallel to the situation in leafy plants where removing the top bud allows the side ones to develop. The white potato is a stem, botanically speaking, since it bears buds (the eyes).



Try cutting up a potato, leaving an eye in each section and planting them. (This is the way the farmer plants his potatoes.) Several potatoes will furnish enough eyes for each child to have one. Allow one uncut potato to lie on a shelf, and compare it with the planted pieces over a period of several weeks.



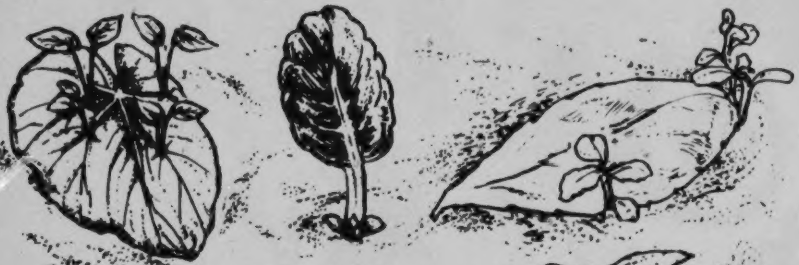
Sweet potatoes and yams will grow in water and produce beautiful vines. (Some potatoes have been treated to prevent sprouting, so start several.) Immerse the end of the sweet potato or yam that has no purple buds to about one-third of its length in a jar of water. It may be necessary to support the potato above the mouth of an unusually large jar with toothpicks. It is difficult to predict how long it will take to sprout. It may take a month or even more, so do not give up unless it begins to decay. It is also possible to grow white potatoes in water in the same way.

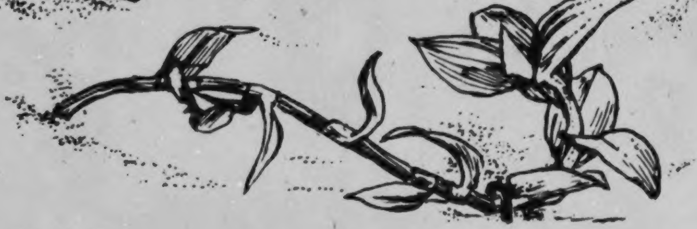
Leaf Propagation

The leaves of African violets and gloxinias will root in water or sand. (These sometimes take a long time.)

Rex (angel wing) begonia can be propagated by cutting across the rib of a leaf that has been laid on moist sand. A new plant will grow from the cut.

New plants will grow from the notches of Bryophyllum (maternity plant). Drop a leaf, or even just part of a leaf, on damp soil, and watch for a circle of new plants sprouting, one from each notch. (This works very well in a terrarium.)



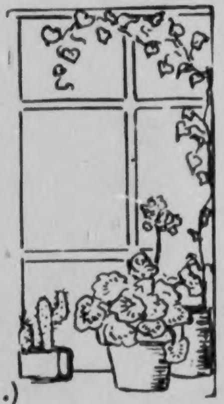


Layering

Layering is a method of propagation that works with most vines — ivy, philodendron, tradescantia. It also works with a jade plant that is long enough to lean over. If the stem is held in such a position that a leaf node touches the soil, it will root there and can be cut away from the parent plant. You may anchor the stem down with a bent paper clip or cover it with some soil.

LIFE CYCLES

Morning glories and wax beans are two of the very few plants that will complete a life cycle within the course of the school year.



If strings are put up at a sunny window, morning glories will climb them rapidly. Morning glories will bloom in two months and produce seeds, which in turn will germinate as soon as they are ripe. As soon as the papery covers on the seeds open, plant the seeds. They will germinate in three to five days and produce another generation. (Be sure to get a mixed variety. Such special types as Heavenly Blue may not produce seeds.)

Plant some wax beans in soil, and grow in good light. Some should bloom and produce pods. Beans from the ripe pods will germinate in a week or less. This provides a very nice example of the life cycle of a plant.

Coleus may produce seed that will germinate quickly. (See p. 11.)

Tiny Tim tomato plants will grow from seed and produce little tomatoes. The seed from these will germinate if the ripe tomatoes are opened so that the seeds can drop on the soil. Cucumber vines will bloom and produce miniature cucumbers, but these will not mature.

SEEDS TESTED FOR CLASSROOM USE

Kind of Seed	Days to Germination	Days to Flowering	Comments
Beans:			
mung	1	--	Excellent for experiments.
kidney, lima	3	30-40	May produce seeds in well-lighted window.
scarlet runner	5	48	Spectacular growth, beautiful flowers.
Citrus fruits (grapefruit, lemon, lime, orange, tangerine)	30	--	Germination time very uncertain; depends on condition of fruit.
Corn	4	--	Excellent for growth measurement.
Cucumber	3	60	Beautiful vine will produce tiny cucumbers.
Grape	30	--	Interesting vine.
Marigold (dwarf)	3	60	Will flower in good light.
Morning glory	3	60	Will produce ripe seeds in 90 days.
Pea	4	20	Does not do well in overheated rooms.
Pumpkin	4	--	Beautiful vine.
Radish	1	--	Seedlings are excellent for experiments.
Squash (acorn)	8	--	Beautiful vine.
Tomato (Tiny Tim)	3	74	Produces young fruit in 85 days. Seeds from mature fruit will grow.
Zinnia (dwarf)	2	60	Nice flowering plant when given adequate light.

COLLECTING PLANT SPECIMENS

You may want to collect whole plants or plant materials for special uses in your classroom. Fruits, seeds and colorful leaves are abundant in the fall. Vacant lots and unmowed rights-of-way along highways and railroad tracks are excellent sources of varied and interesting specimens. (See Warnings below and on p. 24.)

Dormant branches of shrubs and trees can be brought into the classroom in late winter or early spring. Put them in water in good light and watch for the opening of flowers and leaf buds. These materials must not be collected until prolonged cold has broken their dormancy, perhaps by the end of January.

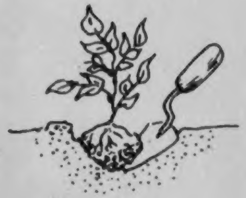
A single spadeful of woodland or bog soil can provide the makings for many terraria. (See p. 12.)

COLLECTION AND TRANSPORTATION

Dried fruits and seeds such as milkweed pods or bare twigs can be carried in the hand or put in paper bags or other containers.

Colorful leaves and other plant parts that you want to mount and display in some way are easiest to carry if you insert them between pages of an old magazine. Identification and notes as to place of collection can be written in the margins of the pages. Many specimens can be collected this way and transported without crushing or wrinkling.

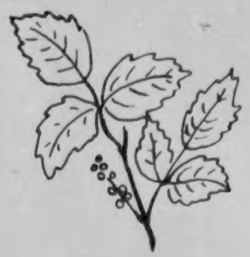
Leafy branches and flowers should be cut with a knife or pruner and placed in plastic bags. Inflate the bags and close with wire twists to keep the specimens moist and cushioned against injury.



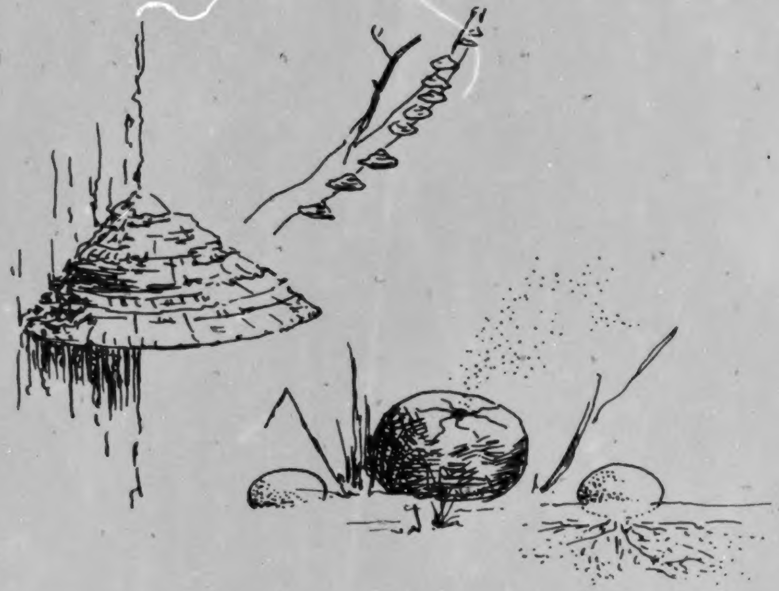
Whole plants should be carefully dug up with a trowel or large knife, keeping as much soil around the roots as possible. Put the plant with its soil into a plastic bag at once. Inflate the bag by blowing into it, and then fasten it. In the case of moss, small ferns or other tiny plants growing on wood or rocks, try to collect a piece of wood or stone along with the plant growing on it, and enclose the whole specimen in a plastic bag as described above.

WARNINGS

When collecting, try to leave the area as undisturbed as possible. Never take more material than you can use. Needless to say, you will not collect plants on private or park property without permission. You should familiarize yourself with the rare species of plants protected in your state.



Know how to recognize poison ivy. ("Leaves three, quickly flee!") If some is touched accidently, wash the skin thoroughly with soap to remove the irritating oils.



Be careful with fungi. You can safely collect any dried and leathery forms of shelf fungi which appear on tree trunks, most odd-shaped fungi, and puffballs. Avoid those that look like toadstools or the edible mushrooms sold in grocery stores. There is a slim chance that you might pick a poisonous one which resembles these harmless forms, and it is better to leave questionable ones alone.

THE END OF THE SCHOOL YEAR

You, your friends, or the school children may want to keep the potted plants that have survived the school year. Discard plants that are in poor condition.

Empty and scrub pots, terraria and window boxes.

Store unused soil, sand and gravel. It is better not to store used soil, since it may be contaminated with fungus diseases and harmful insect pests.

Leftover seeds should be discarded, since the chance that they will germinate diminishes with age. Plan to get new seeds in the fall.

Store dried specimens in boxes.

SECTION **2**

YOUR CLASSROOM ZOO

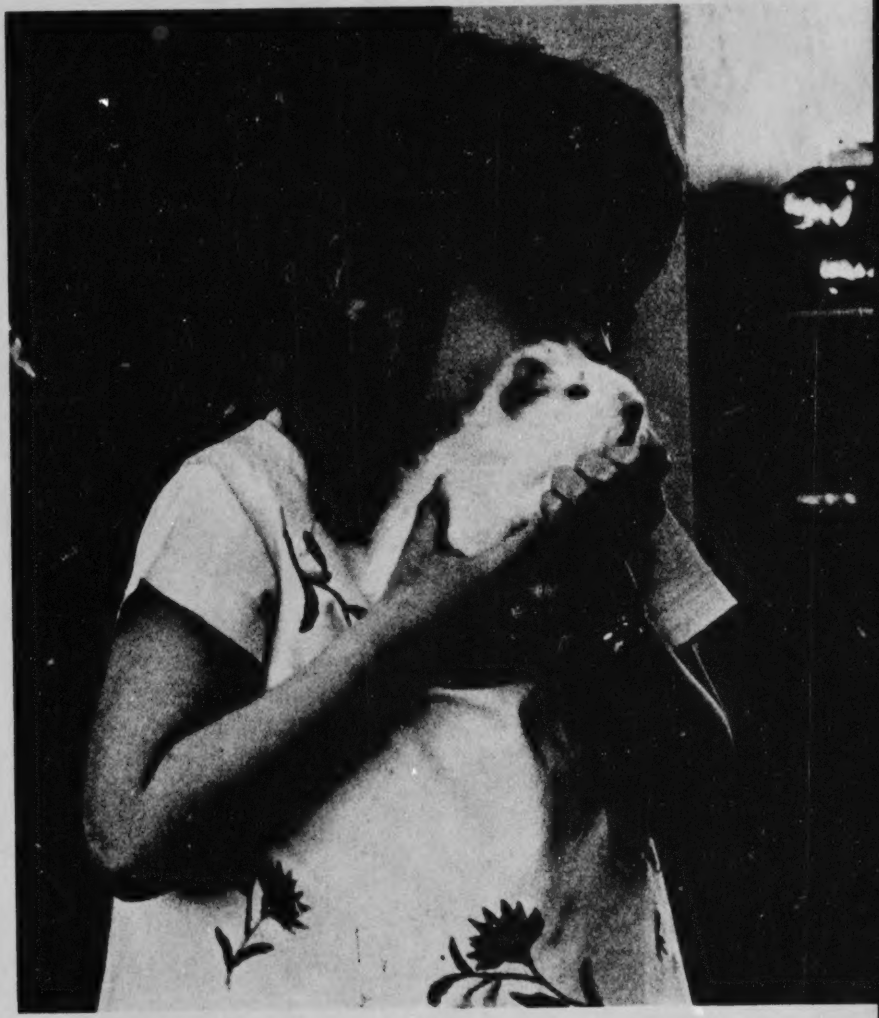
Many living things wiggle. Many are soft and furry. This makes them fascinating for children and wins their greatest interest and attention. On the other hand, to the teacher, the care of animals in a classroom presents problems such as weekend and vacation care, and is sometimes thought more trouble than it is worth. But do not underestimate the worth of direct experience with living things in exciting interest and in developing humane attitudes.

It is possible to find animals that you can feel comfortable with in almost any individual classroom situation. The animals and procedures described here have all been tried successfully in classrooms with average to poor conditions. Some animals require less work than others, but all those recommended are reasonably healthy and hardy.

This section discusses procedures for keeping water animals and land animals. We give details about a group of selected animals that have proved especially useful in the classroom.

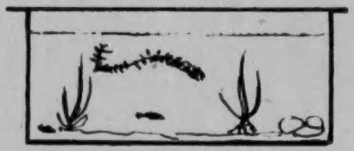
Water animals are simple to care for. They need water, air, a reasonably constant temperature, and food in the right amounts.

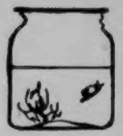
Land animals need more watching and more cleaning-up-after. However, land animals are also more fun. Children can have rewarding experiences taking care of water fleas in a jar of pond water, but they



usually like the bigger, fuzzier animals that are a little harder to take care of. Pick the ones that suit your conditions as well as your preferences.

KEEPING WATER ANIMALS





An aquarium is any kind of container in which conditions are right for water organisms to remain alive. Much fuss is usually made about preparing an aquarium. Fuss may be necessary when the aquarium is to be a permanent establishment intended to last for several years and to contain many kinds of fish. But this kind of aquarium is not recommended for the classroom. Not very much happens in it. Also, too many special requirements result in too much loss when you have inevitable classroom catastrophies such as too much food, inappropriate food, too cold over weekends, too hot over weekends, cover left off, too much chlorinated water added, and so on.

A small aquarium can be set up with an understanding that it will be changed or removed in two weeks. Several small aquaria with different contents can be more interesting than one big one. Larger aquaria set up for long periods can be used to study life cycles of fish and snails and effect of changing conditions on populations.

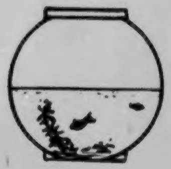
SETTING UP AND CARING FOR AN AQUARIUM

Fish need a great deal of oxygen and a fairly constant temperature. They also need clear water (water without too many suspended particles), and they need food. These needs are simple to provide in an aquarium.

If the aquarium is to be set up for any length of time, put some clean coarse sand or gravel in the bottom before you fill the container. This will trap particles of dead plants, excrement, etc., and help prevent floating particles from being stirred up from the bottom of the aquarium by the fish. Sand should be washed absolutely clean (free of clay, dust, soil, and chemicals) before being put into the aquarium. If the sand is not clean it may contribute more contamination than it takes out. Plants can be rooted in the sand.

CONTAINERS

Any transparent container can serve as an aquarium. Aquaria can range in size from a peanut butter jar to a 10- or 20-gallon tank. An aquarium should not be higher than it is wide, to insure an adequate oxygen supply. If by chance you have an aquarium with a constricted top, be sure not to fill it above the widest portion.



It is wise to keep a cover on an aquarium. A cover keeps animals in (and keeps intruders out). It also prevents excessive evaporation of water. The cover should be loose-fitting or have a couple of holes to allow air to circulate. You might use loose plastic wrap over a small container, and a sheet of glass or heavier plastic over a large container.

Leaky aquaria can be sealed by brushing epoxy glue onto the inside joints. Take the water out first and be sure all the inside joints are thoroughly dry before you apply the glue. Allow to set for 24 hours before refilling with water.

OXYGEN

Most dissolved oxygen comes from the surface of the water. Therefore, use a container with a water-air surface at least as wide as the depth of the water. Plants do relatively little good as oxygenators in small containers (10 gallons and under) unless they are well illuminated 24 hours a day. Plants in an aquarium of this size are mainly for decoration. Bubblers are not necessary unless conditions are crowded.

Fish that come to the surface and gulp are not trying to be friendly or to show you that they are hungry. They are suffocating. This means that there is not enough surface area, or that there are too many fish. It may also mean that the whole tank has gone foul. (You should know if it is foul from other indications, such as the odor.)

TEMPERATURE

Heaters can be obtained to keep tropical fish from being chilled by temperatures below 68° F. But why not use native fish that can take cooler water? (See p. 35.)

Avoid too much heat. Over 80° F. is hard on most fish. A high temperature lowers the amount of oxygen in the water and also increases the metabolic rate of the fish, and thus heightens oxygen requirements.

Rapid temperature changes can kill or weaken a fish. This usually happens when a fish is first put into an aquarium. For safety, float a container with the fish and some of its previous water in the new aquarium water for an hour before dumping the fish into its new environment. This permits the temperatures to equalize.

WATER

Chlorine is often present in tap water (drinking water) in large enough amounts to kill water plants and animals. The water may be freed of chlorine by letting it stand two days in an open wide-mouthed container; or by boiling it 20 minutes, letting it cool, and then stirring it vigorously for 5 minutes; or by treating the water with a few crystals of photographic hypo. (Hypo is obtained cheaply from photo supply stores. It is essentially what you get in expensive small amounts from pet shops under the label of chlorine neutralizer.)

Distilled water will not maintain life very long. Living things need minerals, and the osmotic balance of living cells is upset by distilled water.

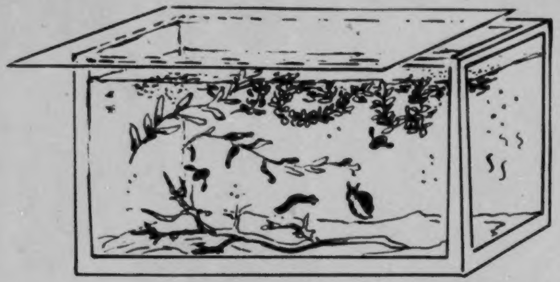
Cloudy water is most often caused by bacteria, single-celled animals, or algae growing in great abundance and suspended in the water. This happens when there is too much organic matter in the water, which in turn is probably due to too much fish food, contaminants dropped in by children (gum, candy, glue, paper), or dead water plants and animals that have not been removed.

The quickest cure for cloudy water is to start over again. The easiest cure is to add nothing to the container until it clears up. But there is a chance that everything will die before the water clears. In any case, be sure to look at the cloudy water with a microscope or magnifier.

Do not mistake algae-coated glass for cloudy water. To have algae in the tank, especially green algae, is a healthy condition. Algae serve as vegetables and protection for a population of microscopic animals. Remove excess algae from the front glass by scraping. Look at the scrapings under a microscope. If you go exploring, you will find a multitude of tiny animals living on the sides of the aquarium.

FEEDING THE INHABITANTS

The food you use should depend on what animals are in your aquarium. Standard tropical fish food is a good mixture for many forms of life. Crumbled dry dog or cat food is similar. Since different fish have different eating habits, find out what your particular fish need to avoid contaminating the tank with the wrong food. (See Bibliography.)



The healthiest and most interesting fish are slightly hungry ones. Never feed more food at any one time than the fish will eat up completely right away. The water then will not get cloudy. It will be more interesting to watch the fish being fed if there is not always excess food around.

Most aquarium animals need to be fed at most once a day; some might need feeding only once a week. Observe yours to see how much they need. Generally, large fish and cold-water fish eat more than smaller fish and those that live naturally in warmer water.

WHAT TO KEEP IN YOUR AQUARIUM

You may stock your aquarium from a pet shop, a bait shop, or pond or stream. Your choice will be governed by the area you live in and the time of year, as well as by your own inclinations.

A NATURAL POND AQUARIUM

This is the simplest and perhaps the most interesting kind of aquarium to set up. It involves getting some material from a pond or lake and dumping it into an empty transparent container or standard glass aquarium. This is called the bucket technique of collecting. No preparation is necessary. Some judgment in selection of materials will increase your chances of success.

At the pond

Take along a bucket or two. It is important to bring back as much water as possible, but do not fill a bucket more than half full. If you fill it full it will be too heavy, and it will spill all over the back of your car.

Dip half a bucket of clear water. Then pick out some bushy, bunched water plants and plop them quickly into the bucket of water. Avoid too much mud and bottom silt, as this clouds the water excessively. Tear out some algae from rocks or posts and dump it in. Take only a little. Too much plant material will start a chain reaction of decay that will foul the water. A handful or two of plants in a plastic pail of water should be enough.

Also collect a few samples of submerged dead leaves, twigs, and algae-covered rocks.

If you have fine, feathery plants that are healthy looking, the job of collecting is finished. You will find that you have collected animals along with the plants. If you wish to spend more time, search and poke for special animals under leaves, in the mud, or swimming about. A small jar or net or kitchen strainer may be of help here. Fish, frogs, and salamanders are not recommended for this collection, for, as you might have guessed by now, most of your aquarium dwellers will be small invertebrate forms easily eaten or disturbed by giants. Again, take only a few. Your aquarium will only represent a very small fraction of the pond. Often one specimen will live well, but several may cause the death of all.

Transportation

The faster you get home, the better. The cooler you keep the water, the better. The smaller your collection of organic material, the longer it will stay alive.

If there is a chance that the water temperature will rise considerably during transportation, ice cubes should be dropped into the pail. The greatest success with this kind of collecting can be had in the wintertime. In regions where ponds freeze over in winter the ice can be chopped to get at plants and animals, and some of the ice can be saved to keep the water from warming too quickly in the car or classroom. (You will find fewer plants in winter, but life is still abundant enough to stock your aquarium.)

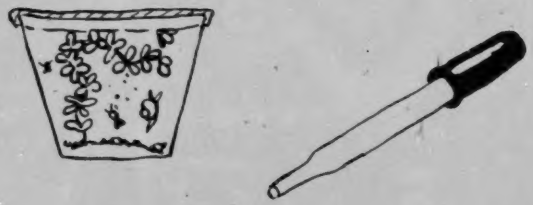
In the Classroom

Tip the bucket and pour its contents into your aquarium. If there is a lot of mud, shake the plants off in the water and let them float free while the mud settles at the bottom of the aquarium. This is to insure that the plants get enough light. It is difficult to root the plants in soft mud, so you can just let them float.

Keep the containers as cool as possible, and allow good light for the plants. Put on a lid but allow an opening for air circulation. Let the whole thing sit until the mud has settled. Then your pond aquarium is ready for observation. The animals make themselves known by their movement. But be alert. They are small and subtle.

A natural pond aquarium should not be fed more than once a week. Use just a pinch of fish food. The animals eat each other and the plants, and also the bacteria that decompose dead plants and animals. By helping the food cycle a little, you can maintain larger populations, but too much feeding will usually increase growth of bacteria and algae to such a degree that the tank will go foul.

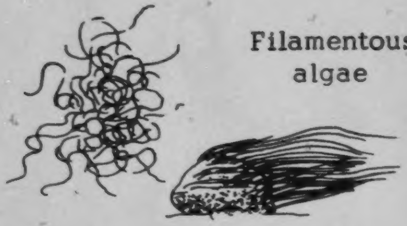
Expect the population to change as time passes. This is all very unpredictable but interesting. Sample materials can be transferred with a medicine dropper or tweezers to micro-aquaria (small containers such as plastic cups or small jars), one for each child.



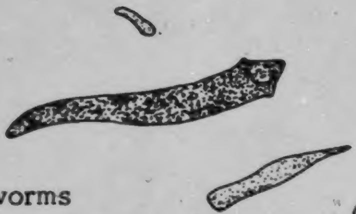
The pond aquarium may run down after a time. If active populations are wanted, it is best to start again in a few weeks with a fresh supply of water, plants and animals.

The natural pond aquarium offers an opportunity to study the effects of pollution. Use several containers filled from the same pond. Care for one as described above, to serve as a control. Add to the others an assortment of pollutants such as might be found in lakes nearby. Detergent is a common pollutant. See what happens when a little is added to a natural pond aquarium. Another pollutant is natural wastes. Wastes serve as food for bacteria, bacteria serve as food for protozoa, and so on. You can simulate this effect by adding too much fish food to the aquarium and watching to see what happens.

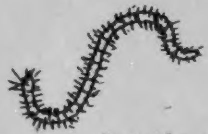
Plants you find in a pond aquarium will include some of those shown on p. 33. In addition, you will find algae.



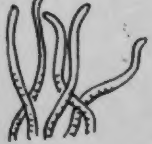
Filamentous algae



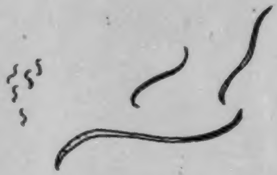
Flatworms (to more than 1 in.)



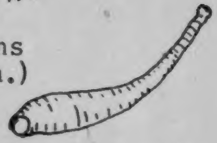
Bristle worm (to $\frac{1}{2}$ in.)



Tube worms (about 1 in.)

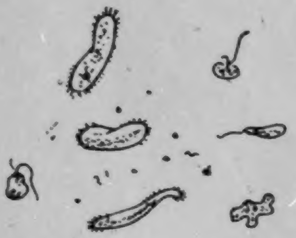


Roundworms (to $\frac{1}{4}$ in.)

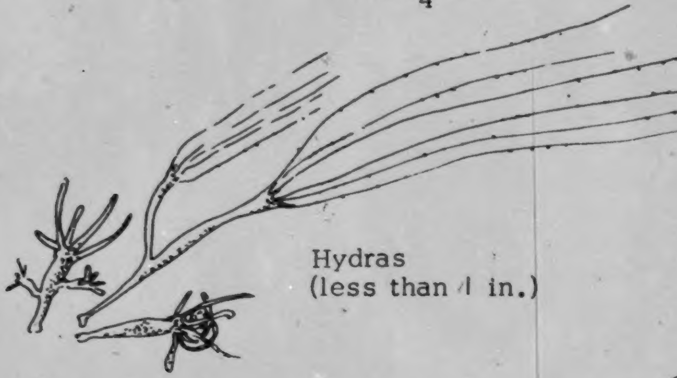


Leech (1 in. to 10 in.)

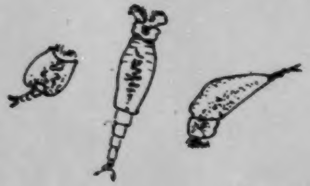
Animals will be found in many sizes. Some can be seen with the naked eye, some with a hand lens, and some with a microscope.



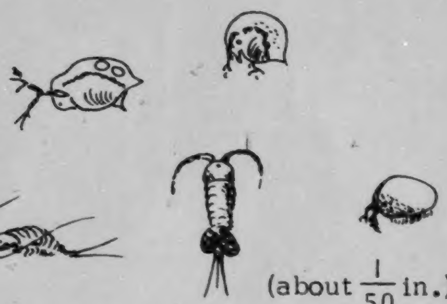
Protozoa (seen through a microscope, 100 x)



Hydras (less than 1 in.)



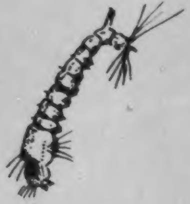
Rotifers (seen through a microscope, 100 x)

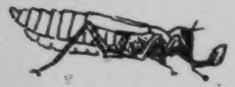


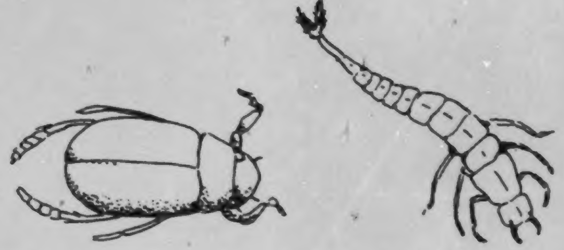
(about $\frac{1}{50}$ in.)

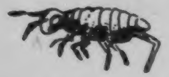
Crustaceans -- Copepods and Water fleas (seen through a hand lens)

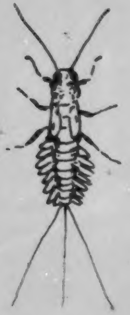
This group of animals can be seen without a microscope. You should find some of them in your natural pond aquarium.

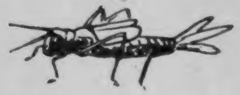

Mosquito larva
($\frac{1}{5}$ in. to $\frac{1}{2}$ in.)

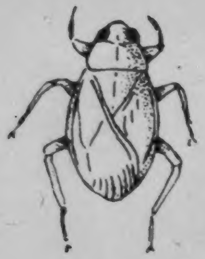

Dragonfly larva
(to $2\frac{1}{2}$ in.)

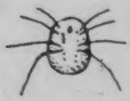

Water beetle
(adult)
(to $1\frac{1}{2}$ in.)
(larva)
(to 1 in.)

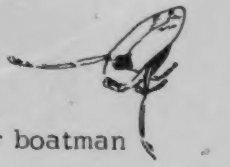

Springtail
(on surface of water)
(to $\frac{1}{5}$ in.)

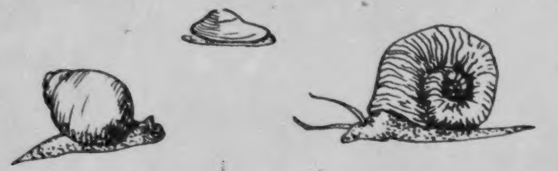

Mayfly larva
(1 in.)


Damselfly larva
(to 1 in.)


Giant water bug
(to 3 in.)


Water mite
(to $\frac{1}{5}$ in.)


Water boatman
(1 in.)


Snails ($\frac{1}{4}$ in. to $\frac{3}{4}$ in.)

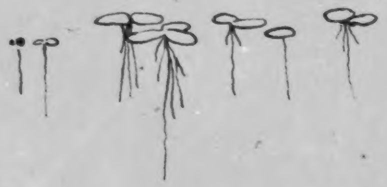
SELECTING PLANTS FOR THE AQUARIUM

Plants serve several purposes in an aquarium besides being decorative. They add to the comfort of some fish who like to hide in them. They help keep the aquarium clean by absorbing some trapped excrement. They may also help supply oxygen in large tanks. A pinch of garden fertilizer sprinkled into the water will make the plant growth more lush.

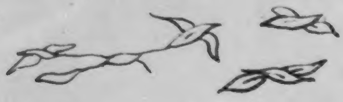
Plants need light if they are to live. Don't keep the aquarium in direct sunlight, but it should be in a well-lighted spot or have its own light source.

Some aquarium plants float near the surface of the water; others live suspended between the surface and the bottom. Still others are rooted. The illustrations on this and the next page are of "tried and true" aquarium plants of all three kinds. They can be found in most freshwater environments, or in your nearest pet shop.

Surface Plants

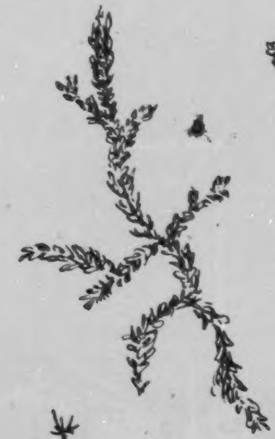


Duckweed

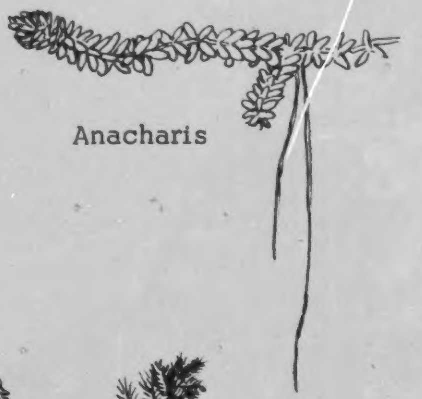


Ivy-leaved duckweed

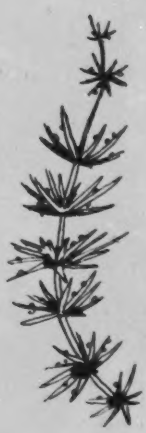
Suspended Plants



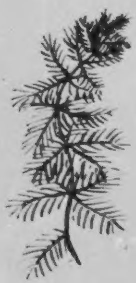
Water moss



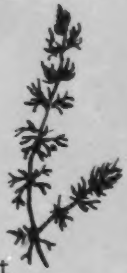
Anacharis



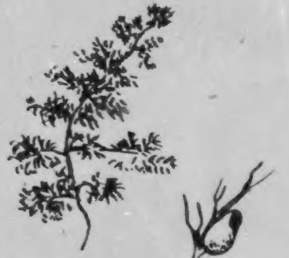
Stonewort



Water milfoil

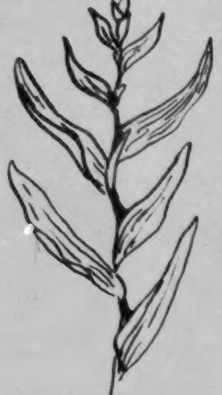


Hornwort

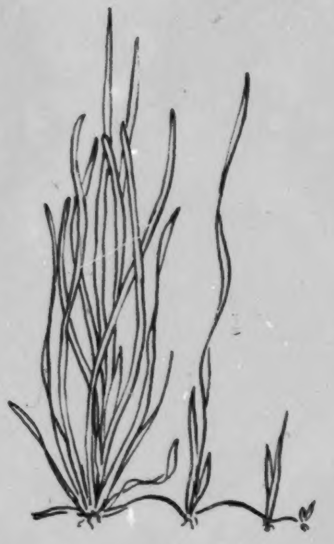


Bladderwort

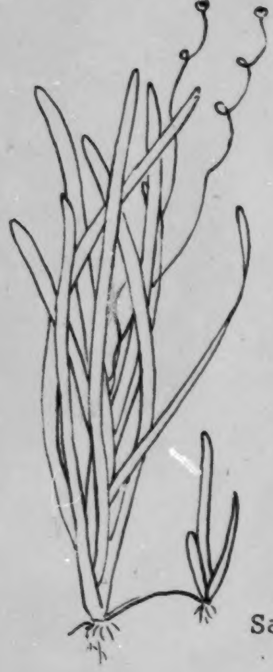
Rooted Plants



Pondweed
(small
species)



Vallisneria



Sagittaria

SELECTING FISH FOR THE AQUARIUM

Some fish will not remain alive in captivity. Others are very delicate and therefore are difficult to keep alive. Fish that can be kept alive easily in the classroom are illustrated here. Some can be obtained from pet shops, some from ponds and streams. Each locality has different representative species which might be used in the same way. Be sure to obtain small, young fish. Young fish that grow too large should be returned to their natural habitats.

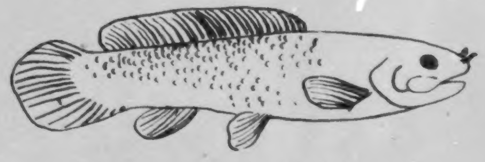
You can get minnows and perhaps freshwater prawns in bait stores. Children in your class can go netting in shallow water, with their parents, to stock your aquarium.

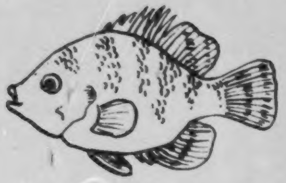
You may choose to keep a single, large fish in a container without plants or sand. This makes the container easier to clean. (Just draw dirt off the bottom with a large baster syringe or siphon it off with a hose.) A few large rocks can be used for hiding places or to relieve the visual monotony for humans. Some animals (such as sunfish) that orient to their surroundings in special ways are interesting to watch if you change the "furniture" around. Crayfish need sand when they shed their shells.

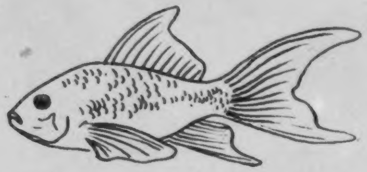
Snails sometimes help an aquarium by cleaning excess algae off the sides and by picking up excess food. They can also be a nuisance. They may eat plants, carry fish diseases and parasites (this is true especially of native snails), become over-abundant, or die. They are interesting to watch, but they are not necessary in an aquarium and they do not eat fish excrement. If anything, when numerous they make more litter than the fish. (See p. 44 for more about snails.)

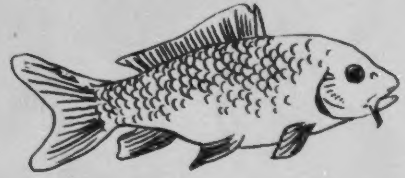
COLD WATER EGG-LAYERS

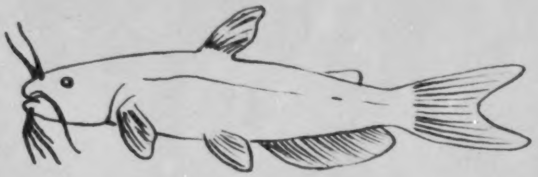
50° - 75° F. Gar eats only live fish. Dogfish and darter eat meat. Others eat fishfood as well as meat.

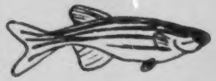

Dogfish
(30 in.)

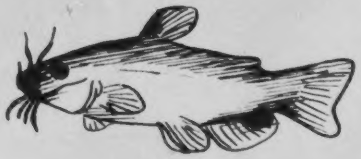

Sunfish
(6-8 in.)

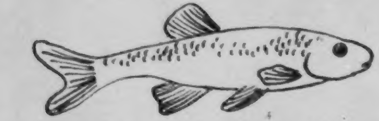

Goldfish (to 18 in.)

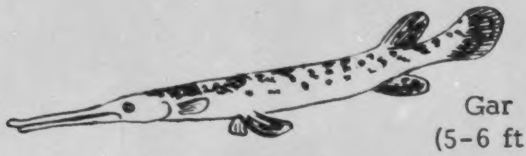

Carp (12-15 in.)

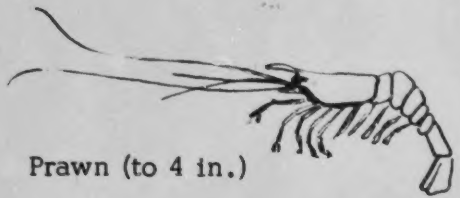

Catfish
(2 in. to several ft.)

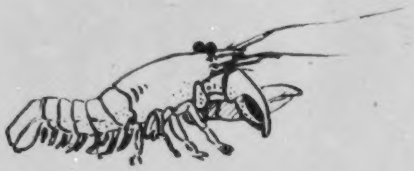

Zebra
(2 in.)

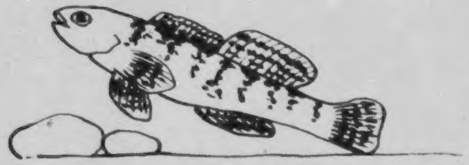

Bullhead
(to 18 in.)


Minnow (4 in.)


Gar
(5-6 ft.)

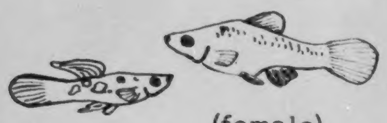

Prawn (to 4 in.)


Crayfish (to 5 in.)

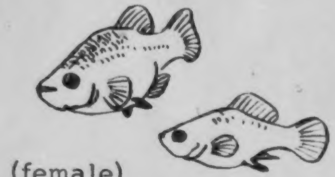

Darter (3 in.)

WARM WATER LIVE-BEARERS

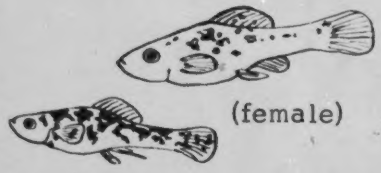
75° - 85° F. Eat fish food.
(These drawings are life-sized.)



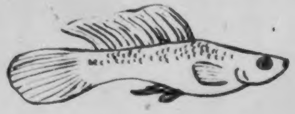
(male) (female)
Guppies



(female) (male)
Moons



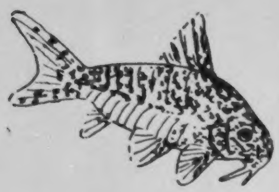
(male) (female)
Mosquito fish



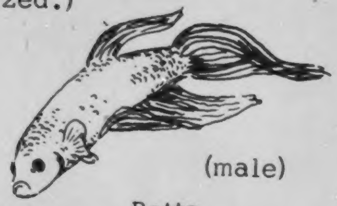
Mollie (male)

WARM WATER EGG-LAYERS

75° - 85° F. Eat fish food.
(These drawings are life-sized.)



Tropical catfish



(male)
Betta

KEEPING LAND ANIMALS

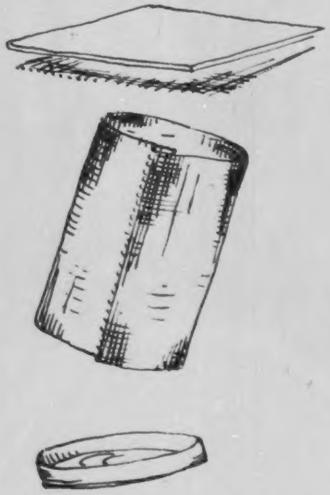
There are times when you will plan to bring an animal into the classroom. There are other times when children will bring them unexpectedly. It is a good idea to be prepared in advance with appropriate containers for them.

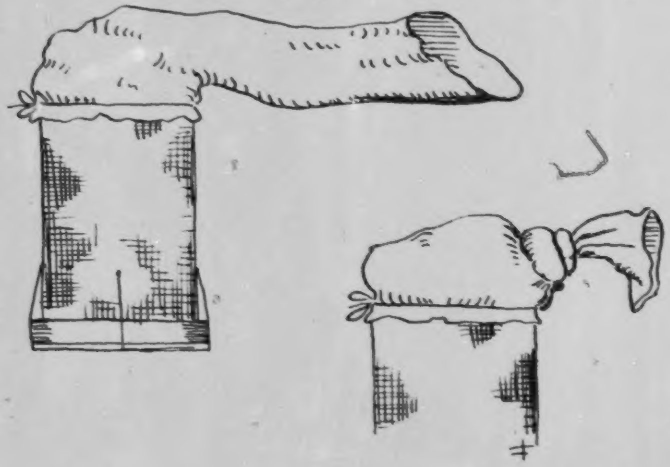
CAGES

A land animal that is kept in the classroom should have a cage that resembles its natural environment at least in a few essentials. An insect or a warm-blooded animal needs a dry cage; a land snail, salamander, toad or earthworm needs a moist cage. If you are in doubt as to what kind of cage a particular animal needs, see pp. 41-60 or the Bibliography.

A DRY CAGE

This is mostly for insects. Use a pie pan, cake pan or can lid for the bottom, and a piece of glass, plastic or screen for the top. The sides are made of a roll of screen. You can tie, hook, sew or solder it down the seam. Wire or tie the bottom to the sides.

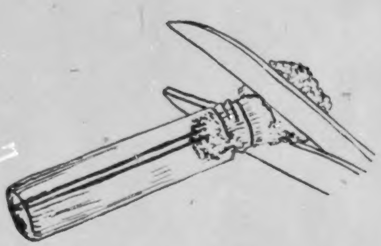




For easy access, you may want to make a sleeve top for the cage. Use a plastic bag with the bottom slit open, a cotton stocking with the foot cut off, or any other sleeve you might devise of cloth or plastic.

Attach it to the top of the cage by sewing, or with glue, string, or binder. The open end of the sleeve should be closed with a wire twist or rubber band that can be removed and replaced easily.

Providing Water

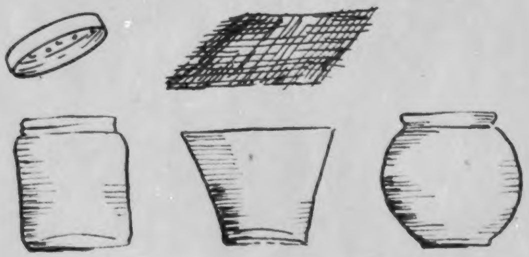


Even in a dry cage you will have to provide water for the animals. Insects usually fall into open containers of water, but almost all insects are able to sip water out of a piece of wet absorbent cotton or paper towel. The best way to keep cotton wet continuously is to stick a tight wad into the mouth of a bottle of water and then tip the bottle on its side. Trim the fluffy edges of the cotton wad with scissors so the insects can reach the wet fibers.

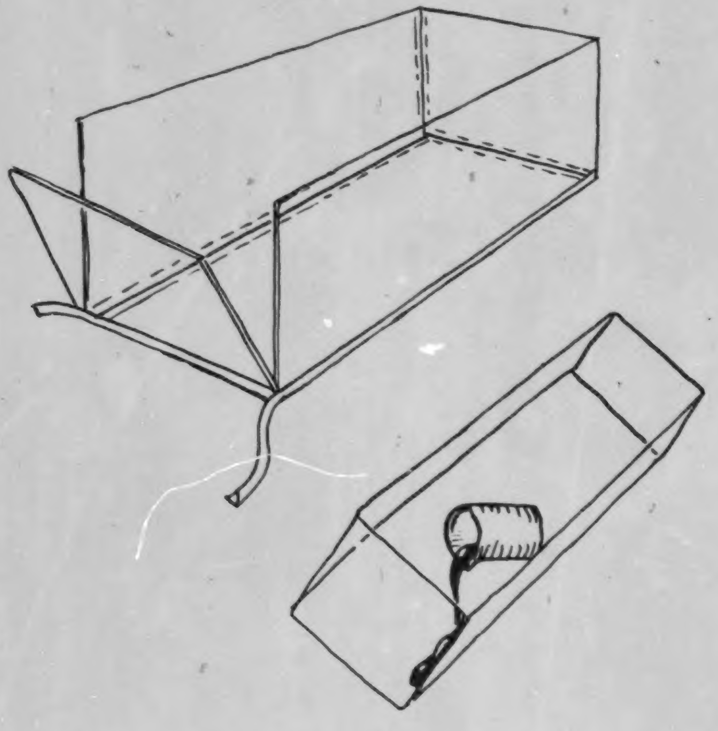
In nature insects get water from rain or dewdrops, from plant juices, from what they eat, or from the soil. Therefore, if it is convenient you can sprinkle the inside of the cage lightly with drops of water once or twice a day.

A MOIST CAGE

Any glass or plastic container with a wide top can serve as a moist cage.



A screen lid will keep animals from escaping. A metal or plastic lid will help retain more moisture than will a screen lid. But if you use a solid lid, you must be sure that it is punched with many holes for good air circulation, or everything in the container will go either moldy or sour.



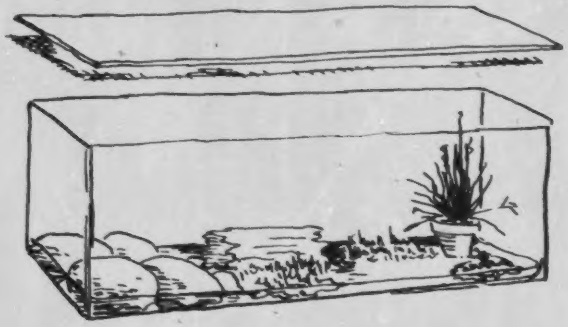
Plastic shoe boxes are ideal for medium-sized moist cages.

To make a transparent container of other sizes, you can use glass or plastic sheets. Acrylic plastic can be glued with model airplane glue or other appropriate cement to make a box.

Other plastics or sheets of glass can be put together with tape to make a box. Water-seal it with melted pitch (tar) or beeswax. (Paraffin is not tacky enough.) To seal, heat the sealer in a tin can with a pinched lip. Tip the box and pour a stream of melted sealer along each joint on the inside. Epoxy glue can be used as a sealer.

This kind of cage is not strong enough to hold together if filled to the brim with water. But if you do a good job, it should be able to hold up to an inch of water without leaking.

Place rocks, water-soaked wood, and moss in the bottom of the moist cage. Do not use soil or sand, Any plants you want to include should be potted in their own small containers. Following this general outline, you should have a cage that can be cleaned easily and will not contain materials that will rot or decompose in the wet conditions.



Cleaning

When keeping larger animals such as frogs, salamanders, turtles, or snakes, clean out the cage and wash with soap once a week. For more details, see the directions for keeping special animals, beginning on p. 47.

Temperature

You can control temperature in a moist cage both by selecting a proper location in the classroom and by adjusting the opening at the top of the cage to provide more or less ventilation. The cover of a moist cage should never be sealed tight.

Use a thermometer to keep a careful check on the temperature in the cage, especially if the cage is in the sun, because sunlight (or even an incandescent lamp) can quickly raise the heat inside to a lethal level. To cool the cage, increase the cover opening. When you need a wider opening for ventilation to allow the escape of the heated air, watch that the cage does not dry out.

The heat over a radiator is usually too erratic for good living conditions. If the cage is to be warm all the time, a shelf or table in an inside corner of the room is the best location. An incandescent lamp can be adjusted to provide both heat and light. If only light is wanted, a fluorescent lamp is better because it is cooler.

To keep a cage cool, set it on a windowsill. The downdraft of cool air, even when the window is closed, will keep the cage cool. But be careful not to let it freeze in winter.

COLLECTING LIVING ANIMALS

Special animals for your classroom zoo can be purchased, but in order to encourage the students to feel involved and to be knowledgeable about what lives in their own community it is important to collect some local animal life — the kinds of things that the children often come upon when they go exploring or when they are playing close to the ground.

An animal is fascinating in itself, but it is important to realize the relation between the animal's needs and behavior and the place where it lives. Only an animal that is found and collected near its own home can be observed, at least briefly, in its natural conditions. Then you can see whether it lives in a wet or dry place, if it eats leaves, etc. It is important for the children to be aware of these relations between the animal and its environment, and they will be more likely to notice them if they do their own collecting.

Following are some simple ways of capturing living things successfully and transferring them to the classroom for study.

SMALL ANIMALS THAT MOVE QUICKLY

If the animal is not moving too fast, you can usually sneak up on it with a small jar in one hand and a cover in the other. Get the animal between the jar and the cover, and when you are close enough to be sure of your aim, quickly close the lid.

Many animals (especially insects) detect your movements easily, but it is possible to sneak up on them if you move slowly. Many insects can be caught while they are busy on plants and flowers.

If the insect is both alert and a good flier (as is the butterfly), it may be necessary to use a net. But it takes a lot of leg work to chase insects with a net, and we recommend this kind of collecting only to those with sufficient time and energy.

An easy way of collecting insects with a net is called "sweeping." Swish the net back and forth through the tops of long grass and weeds, always keeping the opening of the net moving forward. You collect a lot of weed seeds this way (which may be interesting too) but you also can get several hundred insects of different kinds that you can see crawling and leaping about in all directions when you invert the net on the ground. If you wish to keep some of the insects, invert the net over the mouth of a large plastic bag or jar and shake the insects out of the net.

SMALL ANIMALS THAT CRAWL OR HOP

Snails, slugs, earthworms, caterpillars and small toads can be picked up with the fingers. If you are squeamish about this sort of thing, they can be coaxed into a jar or plastic bag with a stick or a piece of stiff paper.

When using a plastic bag as a container, blow it up before tying off the top. This insures that there will be enough oxygen (even from your breath) to last the animal for an hour or two. The cushion of air also keeps it from getting squashed. Be sure to keep closed containers out of the sun, as they heat up very rapidly by collecting the sun's heat energy. (This is called the greenhouse effect.)

SMALL ANIMALS THAT SWIM OR CLING

If you hunt and pick in small spring ponds or around rocks and weeds in streams and lakes, you may turn up many interesting creatures that give themselves away to a careful observer by their movement. Bend down close to the water, because many creatures are small and inconspicuous.

The handiest catching device is a small aquarium net. You could also use a tea strainer or a small plastic cup. Carry several plastic bags along to hold your collection. Put some water in a bag and add a couple of specimens. Blow in about three times as much air as you have water, and tie a knot in the top of the bag. This package can be carried in a pocket (if you don't sit on it) or in a pail, box, or shoulder bag.

Back in the classroom, these animals can be put temporarily in a small container for observation, or they can be placed in an aquarium. (See p. 26.)

SAMPLES FROM NATURAL HABITATS

There is an amazing variety of tiny living creatures that are usually difficult to collect individually but become evident a few days after a sample of their natural habitat is brought into the classroom.

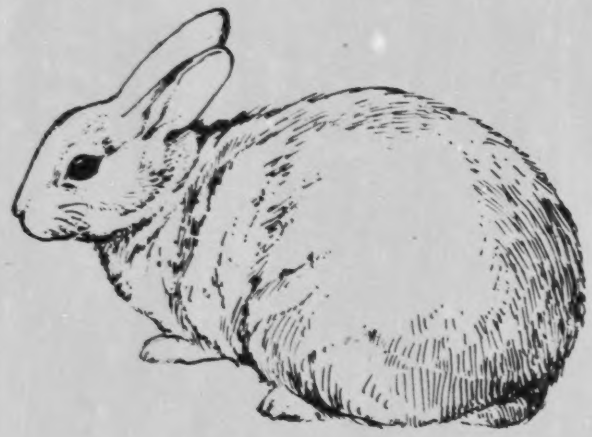
Here are some such samples that can be collected, carried back in a box or plastic bag, and placed in a moist cage for class observation:

1. Moist and half-rotted dead leaves.
2. Soil from the woods.
3. Soil from a swampy place.
4. Garden soil.
5. Sandy soil and plant debris from a vacant lot.
6. Dry rotted wood or a moist piece of rotted log.
7. Dry animal dung.

LARGER ANIMALS

It is not recommended that you collect native animals larger than those you can pick up with your fingers. It is difficult to care for them, and classroom conditions may be a hardship and can result in death. The death of a larger animal may be more distressing to the children than that of simpler forms of life. In addition, moderation in collecting, exhibited by leaving more easily identifiable animals in their proper places in the wild, is good conservation education.

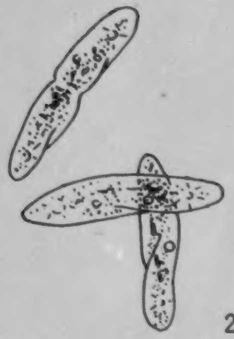
Large animals such as rabbits or ducks should be encouraged in the classroom in the form of tame pets visiting for a day and then returning home with their owners. Pets are easier to handle and observe and are far easier to care for.



ANIMALS SUITABLE FOR THE CLASSROOM

An animal that serves a special demonstration or observation purpose or is to be kept as a classroom pet should be carefully selected for its suitability to classroom conditions. There are many animals other than the recommended ones that the children are likely to bring to school (for example, turtles, chipmunks, white mice). Many of these are either too difficult to keep healthy in the classroom or are messy or undesirable for some other reason. If the children bring in animals that are not included in the groups on the following pages, it is usually best to welcome them as visitors for the day, and then have the children take them back to their natural habitats.

We give here a number of animals suitable for keeping in the classroom, directions for their care, and suggestions for activities and observation.



200 x

PARAMECIUM

The paramecium is a single-celled, almost microscopic animal that lives in pond water. It is well-suited to classroom use because it is easy to culture, it shows how tiny life can be, and it demonstrates interesting and clear-cut reactions to certain stimuli.

If you hold the glass container up to a strong back or side light, you can barely see paramecia with the naked eye. They appear as small pinpoints of light, and can be detected by their movements.

Small cultures of Paramecium caudatum can be purchased from biological supply houses. They can be cultured in great numbers if you provide proper food. You can also use a dropper to isolate individual animals from pond water, and use them to start your cultures.

To provide a growing medium for the paramecia, put some hay, long dry grass, or lettuce into enough pond or lake or aquarium water to half-fill six or more jars. Sterilize the water and the plant material by boiling for 20 minutes. This will make a tea that provides food for bacteria on which the paramecia feed. (Bacteria spores will get into the jar from the air after the culture water cools.) When the water is cool, pour it into the jars together with a few pieces of the boiled grass or lettuce, add the paramecia, and let it sit for a week or more. Paramecia grow best in a dark or dim place.

Use loose covers or glass plates slightly ajar over the containers to avoid evaporation of water. Keep in a cool place. If any mold grows on grass sticking out of the water, remove the pieces of grass. Stir up the culture occasionally to break the surface scum.

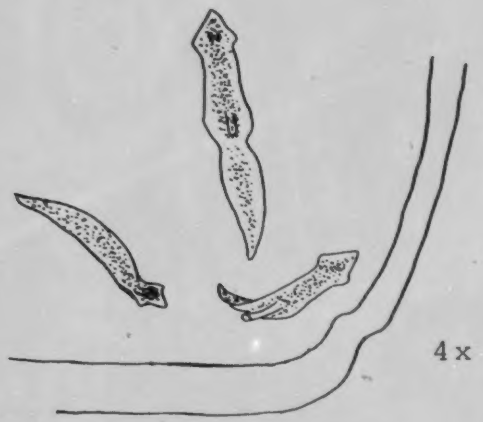
The culture will die out as the paramecia use up the food, so every two weeks new cultures should be made. To do this simply transfer some of the paramecia from the old culture to a fresh supply of the growing medium.

Observe the culture under a microscope or hand magnifier. To prevent rapid movement under the microscope, mix a drop of culture water with a drop of methyl cellulose paste and cover with a cover glass. (Methyl cellulose can be obtained from biological supply houses or from wallpaper stores.)

You can see many organisms with the naked eye if you spread a few drops of culture on a glass plate and hold it over a dark surface. Illuminate this from the side. Introduce weak salt, acid, base and other solutions (vinegar, soap, soda pop, etc.) at one end of the glass plate, to show patterns of attraction or repulsion. Observe responses due to temperature or light-intensity differences between the two ends.

OTHER TINY ORGANISMS

Many kinds of tiny animals can be cultured by just adding grass or lettuce to pond or aquarium water. In this case do not boil the water, because you want to culture the organisms in it. To get a greater variety of life, scrape the side of the aquarium or pick up a small amount of debris from the bottom. The population in this culture will change in time as the food supply or predator population favors one or another kind of animal. Observe these organisms as you did the paramecia. (See above.)



PLANARIA

A planarian is a small freshwater flatworm that lives in streams. It is between one-fourth and one-half inch long. It is easy to keep, it has interesting behavior, and it exhibits regeneration of parts of the body.

You can obtain planaria from biological supply houses. To collect your own specimens, take some water with plants and debris from a lake or stream. Leave it in a shallow pan to settle. In a day or two, planaria should crawl on the side of the pan or come to the surface of the water. They can then be transferred to a jar or a culture dish half-filled with clear aquarium water, where they will grow well.

Feed your culture twice a week with one or two tiny pieces of raw beef liver for each container. It is easy to cut small bits from liver that you keep frozen. Leave bits of liver in the container with the planaria for about an hour. Then remove the liver.

Replace all the water with fresh aquarium water. (It is easy to pour the water off, because the worms stick to the jar.) It is important to do this after each feeding. You must remove the meat juices that seep out of the liver, in order to prevent the water from becoming foul.

The container with its planaria culture should be kept in a cool and dimly lit place.

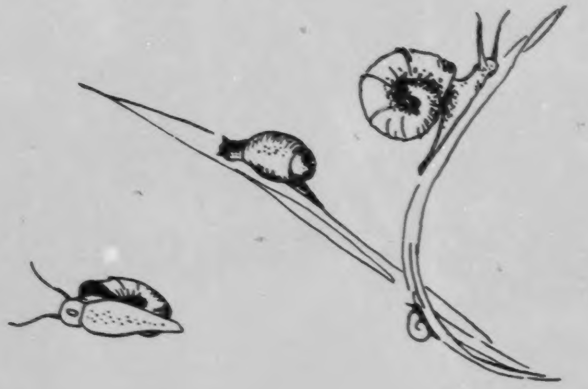
When a planarian gets large enough, it splits in half, usually across the middle, to produce two individuals. A healthy culture of worms will multiply rapidly.

Some activities your class can do with planaria are suggested here:

1. Observe how a resting planaria will respond to liver that is put gently into the container. The planaria detect food by a sense of "taste" in the head region.

2. Planaria will move away from strong light. They will detect the light with eye spots. These are not true eyes that see images. They are light-sensitive nerve endings connected to the brain.

3. Observe the gliding movement of the planaria. They glide by means of muscle contractions and also by the movement of cilia (microscopic hairlike extensions of cells). The worms can glide on the surface film of the water.



SNAILS

Local freshwater pond snails are easiest to keep. European red ramshorn snails can be purchased at aquarium shops. Large exotic snails are interesting but they are harder to keep alive, and when they die they make a larger mess.

Snails will do best in algae-coated containers. To prepare one, let a container of pond water sit in the sun or bright light until its sides are coated with algae. The snails eat the algae and microscopic organisms. You can also give them a pinch of fish food every two days and a piece of lettuce every week. If you do not use pond water, prepare the water as for an aquarium. (See p. 27.) Do not use untreated tap water.

Fish will often eat or bother snails. The snails exhibit the most interesting behavior when they are kept without fish.

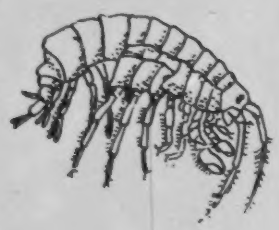
Snails are useful in the classroom because they can be picked out of the aquarium and placed in a small jar for children to observe. Children can watch closely to see the use of feelers, muscular movements of the foot and the action of the mouth on the surface of the glass.

Many snails breathe air from the surface, although some snails have gills. They may be seen at the surface, opening a sac-like lung on the side of the body to exchange air. Some snails have a long tube that is stretched up for air when the snail approaches the surface.

Snails are interesting in that they demonstrate reproduction by eggs. Most pond snails are hermaphroditic — that is, an individual animal has organs for producing both eggs and sperm. Often snails can be seen side by side and attached to each other, trading sperm through short tubes. Following this, both snails will lay many eggs over a period of several days. The eggs will be laid on the glass and on the plants.

The eggs can be scraped off the glass and placed under a microscope to observe successive stages of the embryo's growth inside. The most striking observation is one that can be made with a strong hand lens. The small snail can be seen crawling round and round inside the egg just before hatching.

Soon you should have more snails than you need, and the children can take some home for pets.

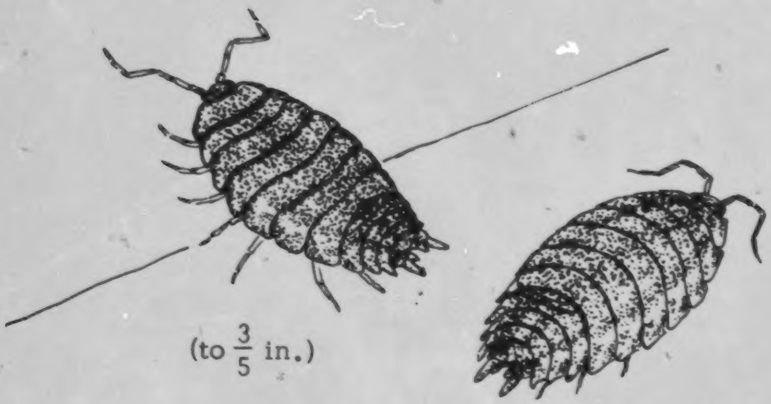


SCUDS

Scuds, or Amphipods, are crustaceans related to crayfish, lobsters, and fairy shrimp. The easiest Amphipods to raise are *Gammarus* and similar freshwater species. These animals are commonly called scuds or sideswimmers. They are small but active creatures. They have many legs which are used for swimming, grasping, and respiration. Place them in a drop or two of water and look at them with a magnifier.

Scuds are most easily kept alone or with snails in a small aquarium or large jar. They can be collected from pond, lake or stream by the "bucket" method. (See p. 29.) Feed them fish food once a week.

Scuds lay tiny eggs which hatch into microscopic larvae. The larvae grow slowly into the adult form. Several scuds will reproduce to form a stable population whose number depends upon the size of the container, the food supply and other conditions. It is interesting to change one condition at a time to see if the population can be increased.



(to $\frac{3}{5}$ in.)

SOW BUGS

Sow bugs (Armadillidium or Porcellio) are small isopods that live in moist soil. They feed on decaying plant material, and so are found in places where there are decaying leaves and wood.

They can be collected outdoors by turning over logs and boards that are lying on the soil, or by separating leaves and humus on the ground. Damp basements provide enough food and moisture for them.

Sow bugs can be baited in a damp basement by cutting two thick slices of raw potato and laying one over the edge of the other in a dark corner. Sow bugs will collect on the underside of the potato slice.

Place sow bugs in a cottage cheese carton, half-gallon plastic ice cream container, or plastic shoe box that has been washed and half filled with soil. Mix broken up or rotting leaves with the soil to keep it loose. Sand can also be used instead of leaves to keep the soil loose. (Adding sand will allow you to find the sow bugs more easily.)

Keep the soil moist and cover the container with a perforated lid to retard drying but to allow some air circulation.

Feed sow bugs on rotting leaves, slices of potato or carrot, or a few pieces of unsweetened breakfast cereal.

Provide some flat slices of potato, leaves or stones for the sow bugs to hide under.

Sow bugs that are collected in early autumn should reproduce by midwinter at the latest. They lay eggs in the debris in their cage, and the young look just like the adults.

Things to observe:

1. They avoid light. If they must search for food in a lighted place, they will run from a suddenly moving shadow.

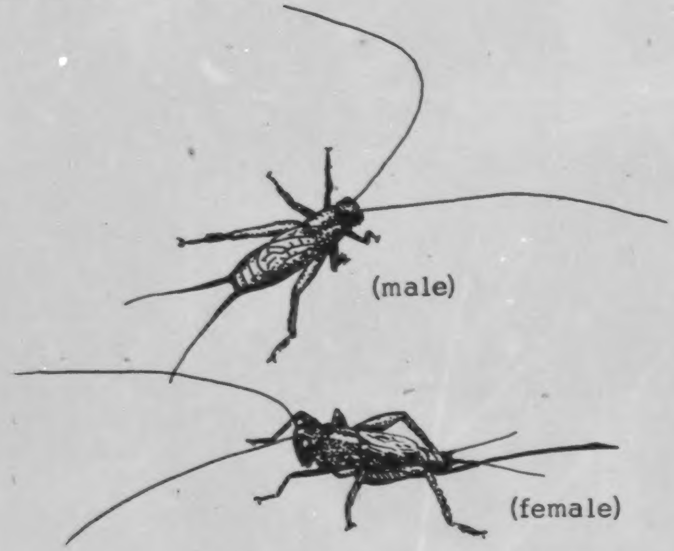
2. Response to moist and dry objects: See which they will cling to or hide under.

3. Note response to carbon dioxide. Blow some of the gas toward them from soda water or a mixture of vinegar and baking soda.

4. Put a sow bug in a box and see if there is any pattern to its response to edges and corners.

5. Observe how the legs move.

6. See how the feelers move. What can they sense? Do they detect chemicals? Try touching the feelers with toothpicks that have been dipped in different substances.



CRICKETS

A continuously reproducing collection of crickets (Gryllus) can be maintained in the classroom. With little effort at least two generations can be raised over a period of three to six months. The best way to start is to purchase a minimum supply of live crickets from a biological supply house. The crickets they usually supply are European house crickets. These are the easiest to keep alive under classroom conditions. It is also possible to find native crickets in basements and fields, but it is necessary to get one to two dozen to insure that you have enough of both sexes and that mating will take place. This should result in the laying of fertile eggs.

Place crickets in a dry cage for insects. (See p. 36.) Transferring crickets from one container to another is much easier if you put the caged crickets in a refrigerator for 10 to 20 minutes to slow them down.

Supply many surfaces in the cage for the crickets to crawl on, cling to and hide under. This will eliminate stress due to overcrowding. Coarse excelsior or crumpled paper towels are good for this.

To feed the crickets, place dry dog food in the cage and supplement this with small bits of fresh apple, celery, and other vegetables. Supply the cage with a water bottle and also sprinkle the cage twice a day. (See p. 37.) It will not be easy to clean the cage because of the crickets' activity, but the crickets do not make much mess if a layer of coarse sand or sawdust is put at the bottom of the cage.

Males will "chirp" to attract females. Fertilization is internal. Females can be identified by the long ovipositor on the rear of the body. They lay their eggs in moist soil. The eggs hatch in one to two weeks, depending on temperature.

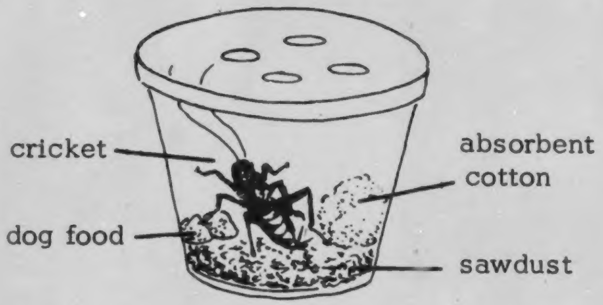
To receive the eggs, place a bowl or box containing at least an inch of soil into the cricket cage. Sprinkle the soil each time the cage is sprinkled. The soil that receives the eggs should be kept moist but not wet.) Females will be observed repeatedly inserting the ovipositor into the soil to lay eggs.

The young crickets are miniature copies of the adult. There is no complete metamorphosis in this insect. The young are called nymphs.

The young crickets can be left with the adults even though some cannibalism will take place. Loss of young is also likely to result because the tiny young crickets will crawl out through the screen of the cage. If you wish, you can transfer the container of soil to a glass container, to retain the young more effectively. If you do this, be sure to provide the adults with more soil for egg-laying.

Care for the young the same way as for adults. The young undergo a series of moults (skin-shedding) during growth. After each moult they appear whitish in color; they darken to brown or black in about a day. Crickets live an average of two to four months. Cooler temperatures (60° to 70°) prolong a cricket's life, but then the life activities are also slowed up.

Each child can be provided with a small covered plastic container containing one cricket, a large pinch of sawdust, a wet wad of absorbent cotton, and two kernels of dry puppy-sized dog food.



The cricket will live in this small cage for several weeks if food and water are provided regularly. Be sure to keep the dog food away from the wet cotton and avoid getting the sawdust wet, or mold will take over. If mold is seen growing, remove the contents, wash the container and start again. When changing containers, remember that cool crickets jump neither so fast nor so far as warm ones.

Observe these things about crickets:

1. Kinds of food consumed.

2. Response to light.

3. Use of antennae.

4. Locomotion.

5. Mating behavior.

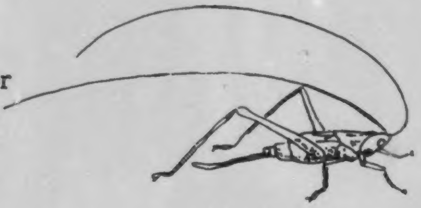
6. Production of chirping.

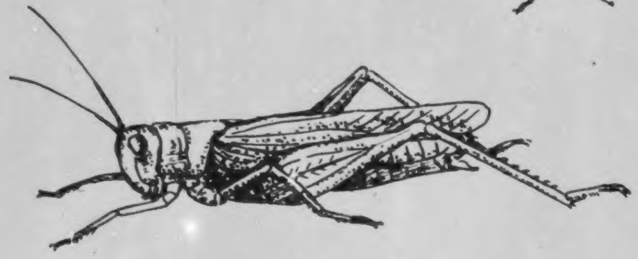
7. Eating and drinking behavior.

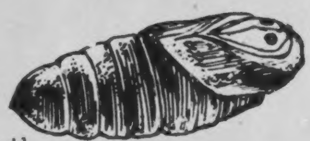
GRASSHOPPERS

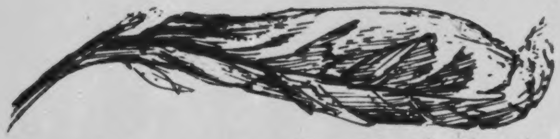
Grasshoppers can be kept in the same way as crickets (see p. 47), but only a few can be kept in each cage. Females already fertilized will lay eggs under the same conditions as crickets. It is more difficult to get grasshoppers to mate in a cage.

Grasshoppers need sunlight to remain vigorous. They are more messy than crickets, and the cage should be cleaned once a week. Grasshoppers can be cooled for transfer. (See Crickets.) They eat a variety of foods including lettuce, sliced apple, tall grasses, clover, newly sprouted grass seed (which can be planted right in the cage) and bran (bran flakes breakfast cereal). They also need water. To provide it, use a water bottle and periodic sprinkling.


Meadow grasshopper


Migratory grasshopper


Chrysalis of giant swallowtail


Cocoon of ailanthus silk moth

COCOONS AND CHRYSALIDS

The bodies of many insects undergo a complete change or metamorphosis during their life cycle. They go from egg to larva to pupa to adult. A caterpillar is a larval stage.

A cocoon is a protective case of silken thread woven by some larvae. Inside it, the insect goes through its pupal stage, protected from its natural enemies and from the weather. Then it emerges as an adult. (Most moths make cocoons.)

A chrysalis is the pupa of a butterfly. The larva fastens itself to a branch or board, hanging head down. Then it sheds its caterpillar skin, and the next skin forms a hard protective covering for the pupal stage. This form of pupa is called a chrysalis. After a period varying from days to months, an adult butterfly emerges from the chrysalis.

You are most likely to find cocoons and chrysalids in the late fall or early spring. Look in sheltered spots — under boards and rocks, on the ground in debris or lightly covered with soil, on fences or houses, on bushes, on tree branches or between ridges on the bark. Most caterpillars eat one particular kind of plant as the main part of their diet, so you are likely to find the cocoons or chrysalids of a particular species near particular kinds of plants. (See Field Book of Insects by Frank E. Lutz for a list of plant-insect associates.)

When you find a cocoon or chrysalis, you will want to keep it under conditions similar to those outdoors. Keep it in a gallon jar, so that when the moth or butterfly emerges it will have plenty of room to spread its wings. Put a one-inch layer of moist soil or sphagnum moss on the bottom of the jar, and then add a few sticks of wood for the adult to crawl on when it emerges. Place the pupa in the jar, above the soil but not touching it, and cover the jar with a piece of screening. Sprinkle lightly.

The temperature at which you keep the cocoon or chrysalis will determine how long the adult takes to emerge. If the pupa is kept in a warm room the adult will usually emerge in about two months' time. If you keep the jar in the classroom during the winter, do not let the pupa dry out. Sprinkle the soil regularly, but be careful not to overwater, or the pupa will become moldy.

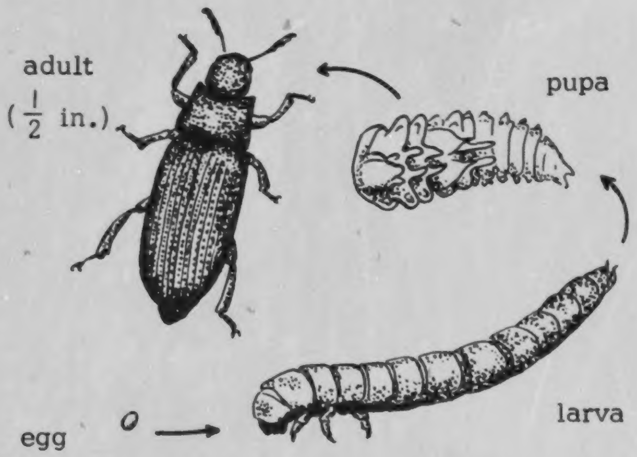
A pupa found and brought indoors in late fall would become an adult in mid-winter. Some adults normally reproduce and die without feeding. Mating would of course be impossible in winter. Others would normally live longer, but you may find it difficult to provide the kind of food they would usually eat. Therefore prepare to kill the insect painlessly by exposing it to vapor from nail polish remover (ethyl acetate) in a closed jar for one-half hour. The insect can then be displayed. (Also see Lutz's Field Book of Insects.)

To allow a pupa to follow its natural course of development, keep its jar outdoors in a well-ventilated, sheltered spot. An unheated garage or porch is ideal. Do not let the sun shine on the jar, or it will overheat it. If no suitable outdoor spot is available, you can delay emergence until the normal time by keeping the jar in the refrigerator.

You can have the children watch for emergence where the pupa has wintered, if convenient, or bring it into the classroom as spring approaches. There is no need to sprinkle the soil in a jar kept outdoors.

After everyone in the class has had an opportunity to look at the adult insect, encourage them to let it go outdoors. If you wish to keep it in the classroom, see the Bibliography (p. 117) to identify the moth or butterfly and find out what it eats. Some adult insects live for only a few days, but others, such as the Monarch butterfly, may live for a year. If the emerging adult is a female it may lay eggs, but these will not develop unless a male is present also.

You may want to try keeping a caterpillar to watch it go into the pupal stage of its life cycle, and then watch for the adult insect to emerge. Your chances for success are best if you find a large caterpillar that may be ready to pupate within a few days. For food for the caterpillar you will need to gather fresh leaves of the kind of plant you find the caterpillar on. These must be gathered fresh daily, or you may try storing some in a plastic bag in the refrigerator.



MEALWORMS

The mealworm (Tenebrio molitor) is the larval form of a beetle that is found in stored grain. Mealworms can be purchased in pet shops in lots of 25 or 50, or from biological supply houses.

To culture, put the larvae in a low plastic container, box or jar of about one quart capacity. (A plastic shoe box is ideal.) Cover the larvae with about 2 cups of whole-grain corn or wheat. Good substitute foods are cornmeal, a mixture of unsugared corn flakes and bran breakfast cereals, or dry enriched baby cereal. Add thick slices of potato, apple or carrot, or apple cores, to the top to provide moisture. Replace these when dry or moldy.

Crumple some paper towelling and place over the food to provide cover and hiding places for the adults. Weigh the paper down with a stone so that it is not higher than the sides of the container, or the adults will crawl out. A cover is not needed if the container has smooth sides, because the adult beetles rarely fly, especially if there is enough food and moisture provided.

Mealworm larvae hatch from tiny eggs that are hard to see because they get covered with dust and debris. The eggs hatch about a week after they are laid. The young are small and difficult to find. They grow slowly, shedding their skins several times. They are shiny, dry, a yellow-brown color, and fairly plump when healthy. They grow to about one inch long before they pupate.

The pupa is whitish in color and is shorter and wider than the larva. It looks like a small, shrouded mummy form. The pupa changes to the adult form in one to three weeks.

The adult beetle is white at first, then gradually turns brown, and finally black. The adults need moisture in order to mate and lay eggs. Be sure to continue to provide slices of vegetable or fruit on the cereal.

The whole cycle will take from three to six months, depending upon temperature, food and moisture. It is ordinarily possible, however, to find a time when larvae, pupae, and adults are present at once.

Surplus larvae can be fed to toads, salamanders, or other insect-eaters in your classroom zoo.

The individual insects can be handled by children on their desks or in small boxes or plastic containers. (Paper boxes provide a better crawling surface than plastic.)

Observations of mealworms may include the following:

1. Life stages and metamorphosis.

2. Response to moisture or dryness.

3. Means of locomotion.

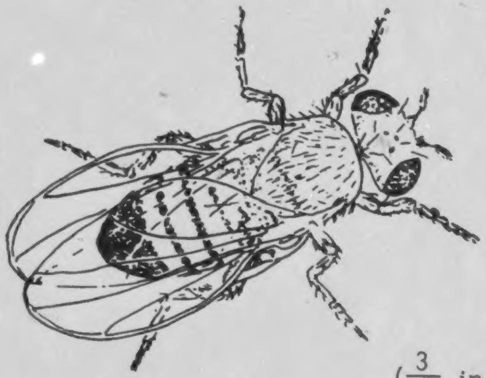
4. Response to barriers.

5. Response to light.

6. Response to a hard surface as compared with a pile of bran.

7. Behavior of adults as compared with behavior of larvae.

Other things to observe are included in Elementary Science Study, Behavior of Mealworms, listed in the Bibliography.



($\frac{3}{16}$ in.)

FRUIT FLIES

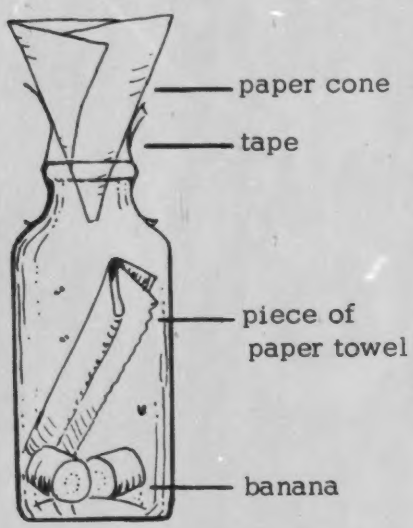
Fruit flies (Drosophila) can be attracted to ripe or decaying fruit during summer and autumn. You may be successful in winter too if the flies have hibernated in the building. It is also possible, but rare, to get fruit which has fruit fly eggs or larvae on it.

To prepare a bottle for fruit flies, place a piece of banana in it, sprinkle the banana with a little dry yeast, add a piece of paper towel for the larvae to climb on, and tape a paper funnel into the mouth of the bottle so that a small opening (about an eighth of an inch across) extends into the bottle.

The flies will follow the odor into the trap, but will not be able to find the small exit. When several flies have been caught, plug the opening of the funnel with absorbent cotton. You may want to replace the funnel with cotton, but if so, you have to move very quickly to keep the fruit flies from escaping.

The captured adults will lay eggs on the banana, and the larvae will hatch and feed on the yeast. Then they climb on the paper towel and pupate there. The complete life cycle takes about two weeks.

More generations of flies can be bred by transferring adults to bottles with fresh yeast and banana. If the banana is mashed into the new bottle so that it will not fall out, the new bottle can be inverted quickly over the old after removing the cotton plug, and the flies will fly upward into their new cage. You may find it easier to observe flies in a smaller bottle without food in it. Transfer them in the same way. For more elaborate fruit fly culturing, refer to Drosophila Guide by Demerec and Kaufman, published by Carnegie Institution of Washington, D.C., 1967, 50 cents.



Observe:

1. Life stages of fly: egg, larva, pupa, adult.

2. Response to light: See how the flies behave when you shine a light on one side of the bottle or slip the bottle into a construction-paper sleeve with a window cut in it.

3. Response to odors: Put spots of different odors in a large container. (Try fruits, perfumes, flavorings.) Transfer some flies to the container and see if they are attracted by particular odors.

4. Response to vibration: Tap the bottle in different ways.

5. Crawling behavior: Watch with a magnifier.

6. Eye color.

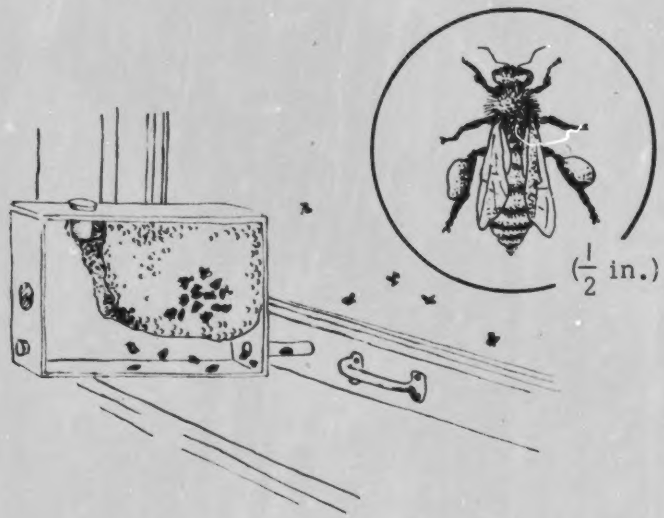
BEES

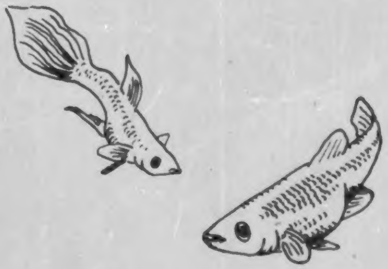
A demonstration hive of bees, including a queen and workers, may be obtainable from your biological supply house. If not, the supply house should be able to suggest a source for a hive.

The demonstration hive is a very handy unit designed to be set inside a window. The bees go in and out through a plastic tube inserted in a hole bored through the window frame. The hive has transparent plastic sides. The comb is inside, and all the activity of the hive can be observed. No handling of bees is necessary.

The hive is small and may need extra feeding with honey to maintain it. (A container is provided.) The most important consideration for a healthy hive is to install it in the spring so that the bees can collect pollen actively during the summer. A hive installed in the fall in cold climates will not show much activity.

Theoretically, the hive should continue indefinitely, but keeping the bees alive through the winter poses special problems of feeding and heating. It is best to replace the bees each spring.





GUPPIES

Guppies (Lebistes reticulatus) are small minnows native to Central America. They are easily kept in the classroom because they can stand variations in temperature from 65° to 90° F., if the changes are not too rapid. Guppies eat a variety of food. They mate readily under almost any circumstances. The eggs are hatched internally, and the young are retained within the female's body. The young are born fully able to swim and feed.

Obtain guppies from pet stores or from the children. (Someone almost always has too many.) Keep them in an aquarium. (See p. 26.) If you have just two guppies, they can be kept in a quart jar. Feed them standard fish food or special guppy food bought at a pet shop. Adults sometimes eat the young, so it is best to provide plants as hiding places.

Observe:

1. How fins and tail work.

2. Differences between male and female: The presence of the gonopodium indicates a mature male fish.

The gonopodium is a modified fin used for transferring sperm. Males are usually smaller and more brightly colored than females.

3. Mating behavior: The male transfers a sperm packet to the opening in the female's body near the anal fin.

4. Breathing: Note increase in respiration rate with warmer water and lack of oxygen.

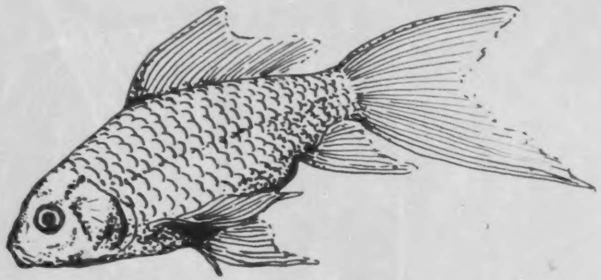
5. Feeding habits: Fish can be trained to come to a particular spot to be fed if the food is always put in the same place. They usually become conditioned to seek food when they perceive motion of large objects (people). See if they will respond in the same way if they are not hungry.

6. The flow of blood in the tail of a young guppie can be easily seen with a microscope. Catch the guppie in a net and wrap it in wet tissue, leaving its tail sticking out on a wet microscope slide. This shouldn't harm the guppie if you unwrap and replace it in the aquarium within 5 minutes.

GOLDFISH

The goldfish (Carassius auratus) sold in variety stores and pet shops are sturdy and easy to keep in the classroom. You will not need aerators or heaters for them.

To prepare your aquarium, set the empty tank where you will want to keep it, in a cool place and out of direct sunlight. Sand or gravel is not necessary, unless you want it for anchoring plants.



Fill the aquarium with tap water. The water should remain in the aquarium at least 24 hours, preferably longer, before the fish are added, so that the chlorine will have disappeared. At this time also fill a plastic bucket or open jug with water which will be "aged" and ready to replenish the supply in the aquarium as it evaporates. You can use a few drops of hypo or the water dechlorinator sold in pet shops to age the water more quickly.

After the water in the aquarium has cleared and has aged for several days, purchase your fish, a dip net, and a supply of fish food. Select lively, medium-sized fish. Check to see that there are no dead or sluggish fish in the tank at the store. If there are, there is a greater likelihood that the fish you buy will also be diseased.

The fish will be given to you in a plastic bag. Float the unopened bag in the aquarium for about an hour before releasing the fish. This allows the temperature of the water inside and outside the bag to equalize. The shock of rapid temperature change will kill a fish.

The usual difficulties with keeping goldfish result from keeping the aquarium too warm, having the fish in too small containers, or overfeeding. Feed the fish only a small pinch of food every other day. Pet shops may recommend enough food to be eaten in five minutes every day, but ordinarily a feeding every other day will be sufficient. It is easy to train goldfish to come for food if you always feed them at the same time and in the same portion of the tank. You can also tap lightly on the aquarium just before you add the food.

If much debris accumulates at the bottom of the tank, siphon it off. If the fish come to the surface and gasp for air, either they are overcrowded or the water has become foul. For the first situation, provide an additional container; for the second, siphon most of the water out and replace it from your aged water supply.

Observe:

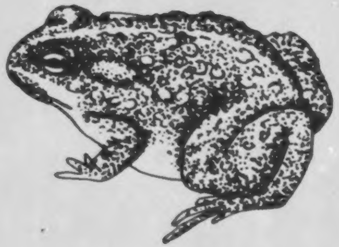
1. How does a goldfish use fins and tail for movement? Which fins are used for moving up and down, which for moving forward? Does the fish move backwards?

2. Note rate of gill movement in comparison to temperature of water.

3. Observe fish from a distance so as not to disturb them, and note the region of the container in which they are most often seen. Observations might be made at five-minute intervals. Do all fish behave this way?

4. Note feeding habits. What makes fish come to be fed?

5. Test for favorite kinds of food. Transfer a fish to a small container, and clean out food that is not eaten. Try small bits of the following: plastic, nails, oatmeal, carrot, wood, insects, hamburger, cheese, cracker, lettuce.



TOAD

The common toad (*Bufo americanus*) makes an excellent pet for the classroom. It will often live for many years.

Keep the toad in a moist cage and provide it with a dish of water to sit in occasionally. (Tap water does not seem to harm toads.) Clean the cage every week with soapy water and rinse thoroughly. Provide some sunshine.

Feed a toad with mealworms, earthworms, crickets and other insects twice a week or more. The more a toad eats, the faster it grows. During the winter beef liver or chicken liver can be dangled from tweezers in front of the toad. If you can dangle the food so as to simulate the movement of a living thing, the toad should eat it.

Keep the cage between 50° and 65° F. (See p. 39.) The toad will then eat less and live longer. It may be necessary to warm the toad to get it to eat. It can be warmed by holding it in your hand. When you pick it up, it may elimate water, but this is harmless. It is an interesting behavior characteristic for protection. The liquid tastes bad and would make an animal drop the toad from its mouth.

Observe:

1. Eating behavior: This is dependent upon the toad's seeing movement. Place a hungry toad on the table and set mealworms in front of it. Watch the use of the tongue to catch food. Observe the toad's use of the front feet to position food in the mouth.

2. Movement and use of legs.

3. That quality of the skin which prevents the toad from drying out. Compare with frog or salamander.

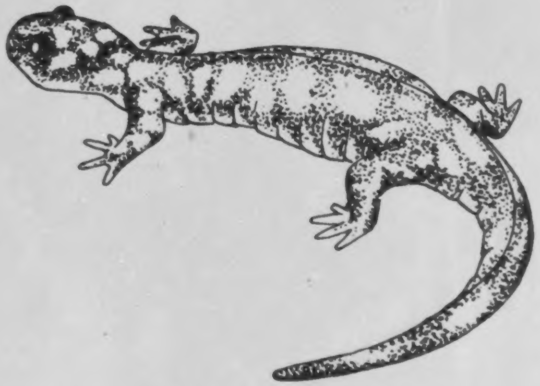
4. Sex differences: Males will usually croak or peep when grasped with fingers behind the front legs, and females will not. The male has large thumbs on the front feet. There is no other simple way of telling sex.

5. Eyes: Eye sockets extend into roof of mouth. Eyes are used to force food down when swallowing.

6. Where are the toad's nares (nostrils)?

7. Does it have teeth? (Yes.)

8. Does it have toenails? (No.)



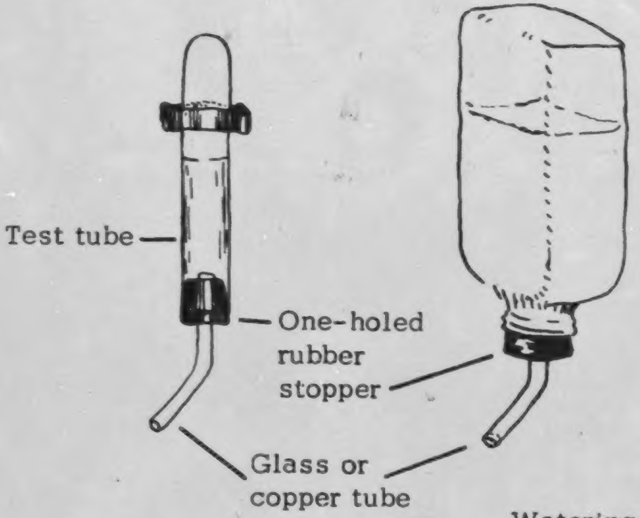
SALAMANDERS

Tiger salamanders and their relatives are easiest to keep, but other salamanders also live well in the classroom. Like toads, they require little attention and eat well. They may be kept even cooler than toads (35° F.) Just don't change the temperature very rapidly. Salamanders require up to one inch of water in the bottom of the moist cage, but otherwise should be treated exactly like toads. (See p. 56.) Salamanders are usually a little more aggressive. They will eat liver better than toads and they may learn to take food without its being dangled.

RATS

The laboratory rat is one of the tamest and most predictable of classroom pets for young children. For school use they are much better than mice. Their soft fur invites handling, and their large size makes them less vulnerable to injury. Also, they have far less odor than mice. They are rarely inclined to nip, as a hamster does, and they do not move with quick, unpredictable motions.

A cage for rats should have a removable tray and a hinged top. Unless you are especially handy at making things, you would do best to buy a standard laboratory cage. Cleaning must be done every day, or odor will build up. A proper cage for easy cleaning has a wire grid bottom that allows droppings and urine to fall through. Wash the cage with soap every week. Provide the rats with a water bottle, not a dish of water. This can be made according to the diagram below or bought from a pet shop. Provide shreds of paper for bedding.



Watering Bottle for Mammals

Feed rats standard rat food, called "lab chow." This is a balanced diet, and since it is a dry, pelleted food, it will keep cage mess at a minimum. Rats will eat almost anything a human will (and a few other things besides), so other food can be offered occasionally as a treat.

The rats you obtain from a pet shop or biological supply house should be young ones. (Rats mature at three to four months and are old at one and one-half to two years.) To tame young rats, you should handle them every day. If you handle them gently and never tease or hurt them, they will enjoy coming out of their cages, especially if they are given a small treat each time. Rats, especially young ones, may occasionally leave droppings when taken out of their cages and handled, but they are much better about this than mice.

A male and a female rat can be kept together in one cage successfully. But the male should be removed when the female has given birth and during the time she is caring for the young. Be sure to handle the male daily to keep him tame. Do not handle the female until the young have their eyes open and are scampering about.

The cage is the rat's home territory. If anything is poked into the cage, the rat, like most rodents, will bite it. He thinks that it is food, or he associates it with an irritant. Be sure that the children do not poke anything, whether fingers or food or pencils or sticks, through the wire, to avoid training the rat to respond in ways that might make the animal unsafe to handle. Teach the rat to come to the door when you open it, by offering a treat each time. Then when you want to take it out you won't have to reach into the cage to grab for it.

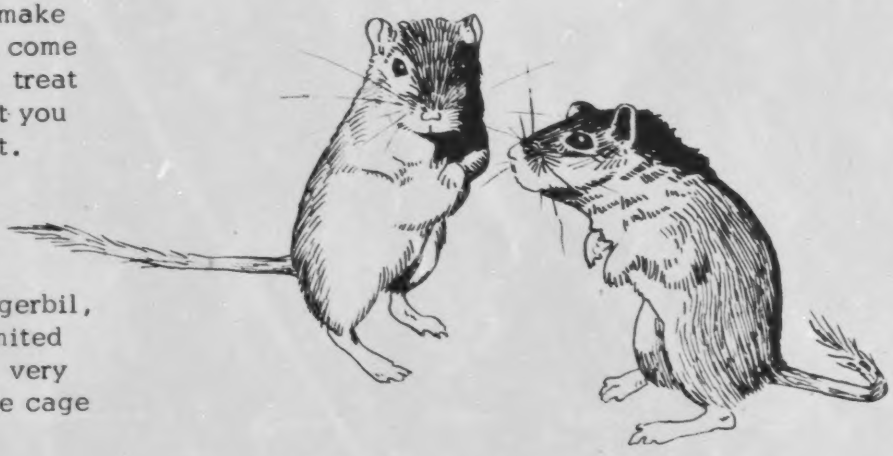
GERBILS

The easiest laboratory mammal to keep is the gerbil, a desert rat from Asia. Gerbils have very limited liquid waste, and their droppings are dry and very small and have almost no odor. Therefore, the cage needs cleaning only once a month.

One drawback for young children is that gerbils are very quick, active animals, and are hard for children to handle. But they are much more fun to watch than most rodents. They are never still a minute, and they are extremely curious.

Gerbils are most easily caged in an unused or leaky aquarium or terrarium fitted with a screen top. In this way they can be easily watched but are protected from teasing. The more room they have, the happier they will be. Put an inch of wood shavings on the bottom and provide paper or cloth for bedding. (They will shred it themselves.) Gerbils like to clamber over and under objects such as paper tubes, tin cans or boxes.

Provide the animals with a watering bottle, not a water dish. (See p. 58.) Keep the cage dry. Feed them "lab chow" (see p. 58.) and supplement it with a mixture of seeds such as hamster food. Give



occasional treats of other foods such as potato chips and dry breakfast cereals.

Buy gerbils from a reputable dealer of pets who will guarantee that he has sold you a young male and female. (It is hard to tell the sex when they are young.) At three months of age, gerbils are ready to mate. It takes 24 days after mating for the young to be born. The male may be left in the cage when the young are born. He will not bother them. Do not handle the females or the young during the period of nursing, which lasts about six weeks. The family group may be kept together indefinitely if the cage is large enough. A gerbil may live one and one-half to two years.

OTHER ANIMALS

Several other animals may also prove to be good classroom pets. If you wish to experiment, we suggest you find out about some of the following:

Hydras
Water fleas (daphnia)
Spiders (web weavers)
Blow flies
Brine shrimp
Parakeets (budgerigars)
Zebra finches
American chameleons (anole)
Hamsters
Snakes

TEMPORARY HOUSING FOR TRANSIENTS

There are animals that you may want to keep for a few days for a particular lesson even though they are not suitable for extended stays in the classroom. The general rule is to keep their cages as much like their natural habitats as possible.

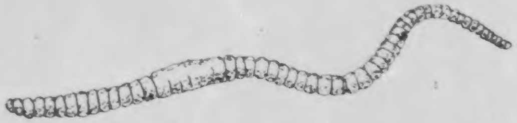
Ants: Keep in a jar filled with moist soil. Set the jar in a basin of water so that ants cannot escape.

Beetles: Keep in moist soil. Cover the container with wire screen, or with a well-punctured jar lid.

Earthworms: Put in flower pots or terraria. They will burrow down, but should come to the surface again if you water the pot.

Frogs: Use a large container, in which you can place water and a rock or other dry surface for the frog to sit on. Cover with screen.

Tadpoles: Keep in pondwater or aged water. They can be put in your aquarium with your fish. Feed with boiled lettuce. (See under Paramecium, p. 42.)



SECTION 3

WHEN CHILDREN BRING THINGS IN

Children often bring things to show at school, either on their own or with some encouragement. These are often living things — a butterfly, an unusual seedpod, a cocoon, a feather. Shells and rocks are often collected by children, and a child may bring to school all or part of his personal collection.

When a child brings a specimen to class, how might you take full advantage of the situation for the educational benefit of both the child and his classmates? This section contains specific suggestions on how to guide the child in making his report to the class, how to stimulate class discussion and speculation about the specimen, and how to help the children get further information about it.

The section deals separately with animals, plants, and rocks and fossils.

WHEN CHILDREN BRING ANIMALS INTO THE CLASSROOM

When a child brings a living animal specimen to school, the following questions can serve as the framework of his report to the class:

IN WHAT KIND OF PLACE WAS THE ANIMAL FOUND? (Wet, dry, sunny, shady, etc.)

WHAT WAS IT DOING WHEN YOU FIRST SAW IT?

WERE THERE OTHERS LIKE IT THERE?

Have the child take the specimen around so that every member of the class can have a close look at it. If the specimen is very small, provide a magnifying glass. When the children have had time to watch how the animal breathes, moves, etc., ask:

HOW DO WE KNOW THIS ANIMAL IS ALIVE?

WHAT IS THE NAME OF THE ANIMAL?

On p. 63 you will find a key to picture charts that may help identify the animal. If it is still unidentified, see the Bibliography for further help. Bear in mind that identification is not a goal in itself but serves as a lead to further information.

WHAT OTHER THINGS WOULD WE LIKE TO KNOW ABOUT OUR SPECIMEN? (How it eats, how it cleans itself, how it spins a web, how it lays eggs, how it builds a nest.)

If part of an animal, such as a feather, a bone, the skin shed by a snake, a pupa case, or a shell is brought in, ask:

WHAT PART OF THE ANIMAL IS THIS SPECIMEN?
WHAT IS ITS JOB?

These questions should generate activity of two kinds: further observation and reading.

Observation and experimentation may be carried on in the classroom. (See p. 90 for museum exhibits of living things, and pp. 42-60 for discussions of specific animals.) To obtain certain information, further observation in the animal's natural habitat may be necessary. In this case have the child who brought the animal take it back to where it was found and observe it and others like it there. (This might be an assignment for a committee.)

The Bibliography suggests sources for further information about animals the children are most likely to bring into the classroom. Also check the index for other references in this handbook.

If the animal brought in is a pet, classroom discussion might follow this pattern:

WHAT BREED OF ANIMAL IS IT?

HOW OLD IS IT?

WHAT DOES IT EAT? HOW IS IT CARED FOR?

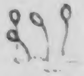
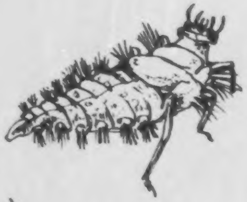
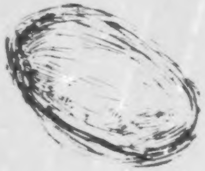
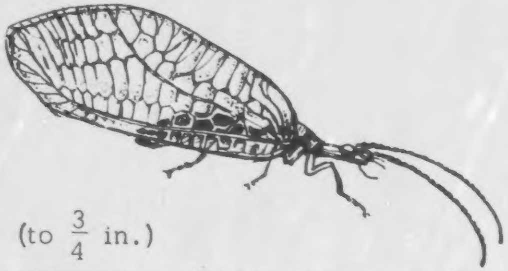
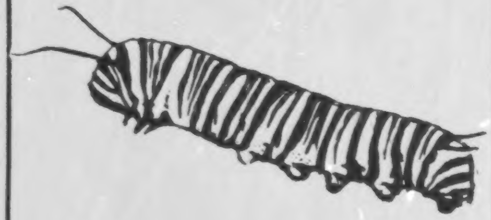
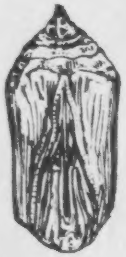
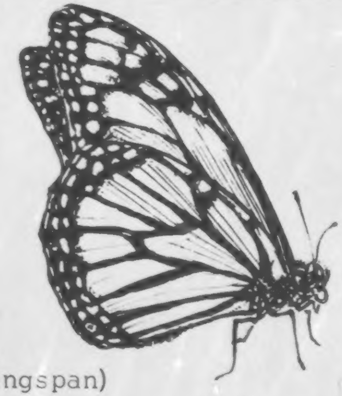
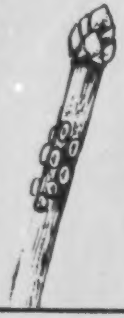
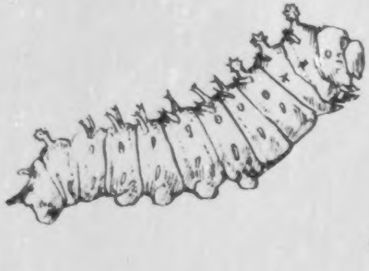
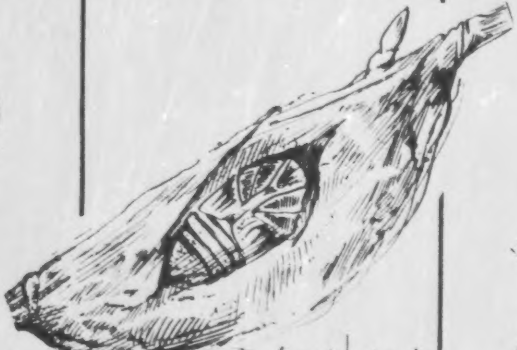
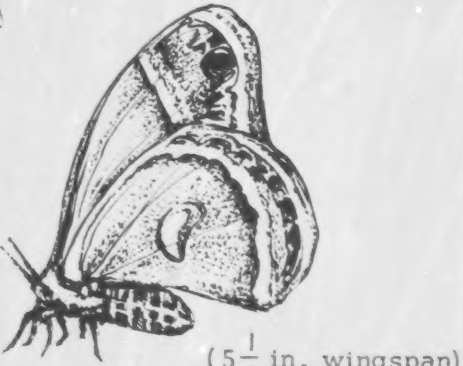
DOES IT HAVE SPECIAL USES?

See p. 25 to help you decide whether you want to keep a particular animal in the classroom or send it home.

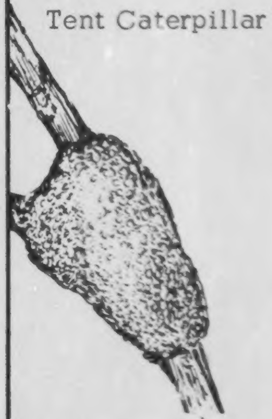
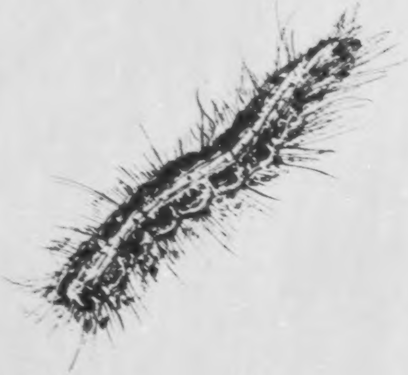
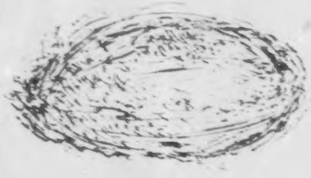
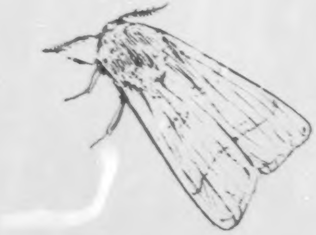
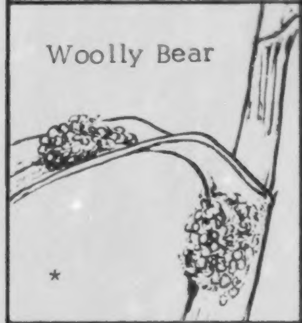
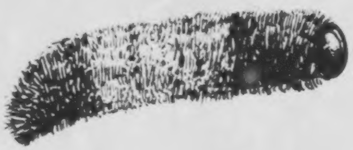
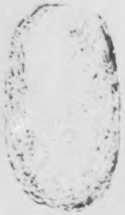
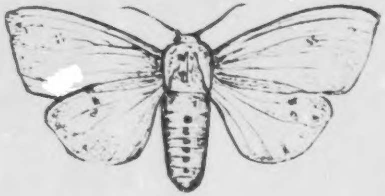
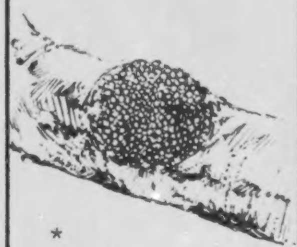
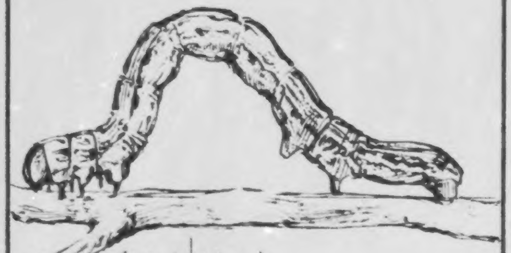
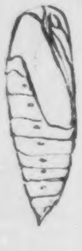
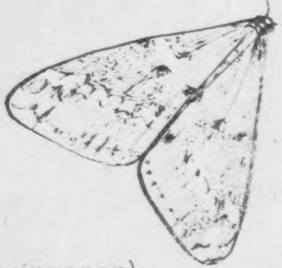
KEY: WHICH ANIMAL IS IT?

COUNT THE LEGS	See Index for information and bibliographical references	Illustrated on pages
Does it have no legs?		
If its body is covered with scales it is probably	a snake	71
If its body is naked (no hair, no scales) it is probably . .	a worm	69
If it has no legs but does have one "foot" it is	a mollusc	70
Does it have two legs and feathers? If so, it is	a bird	—
Does it have two legs and hair? If so, it is	a mammal	—
Does it have four legs?		
If its body has hair, it is	a mammal	72
If its body is covered with scales, it is	a reptile	71
If its body has neither hair nor scales, it is	an amphibian	71
Does it have six legs? If so, it is	an insect	64-68
Does it have eight legs? If so, it is probably	a spider	69
Does it have fourteen legs? If so, it may be	a sow bug	69
Does it have many legs and does it look like a worm?		
If so, it may be	a centipede	69
or it may be	a millipede	69
or it may be	an insect larva	64-68

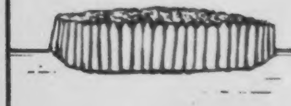
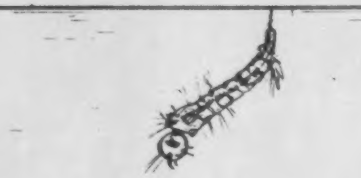
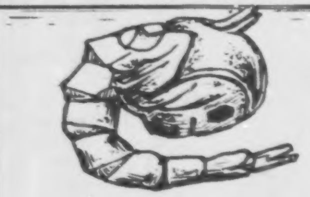
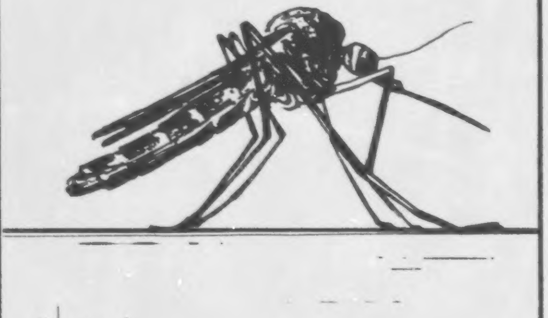
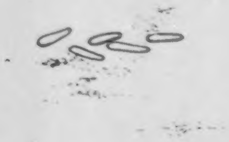
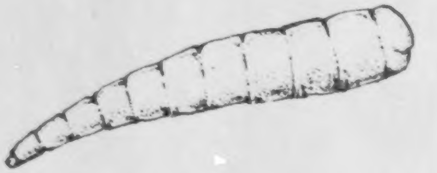
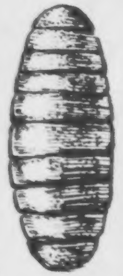
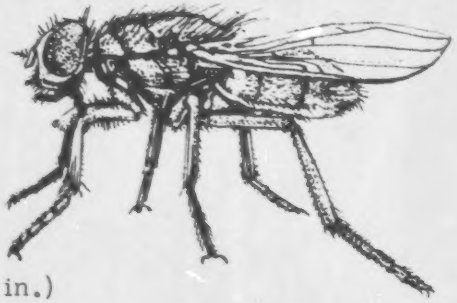
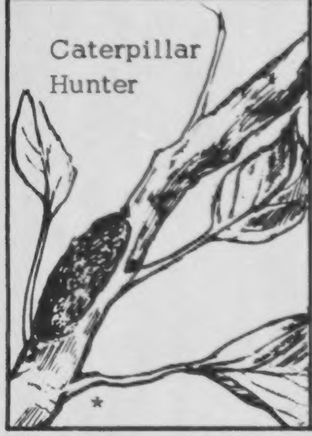
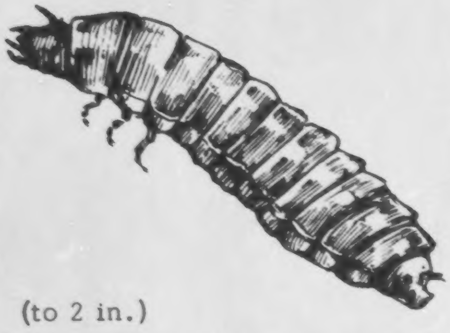
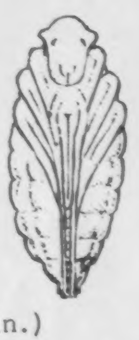
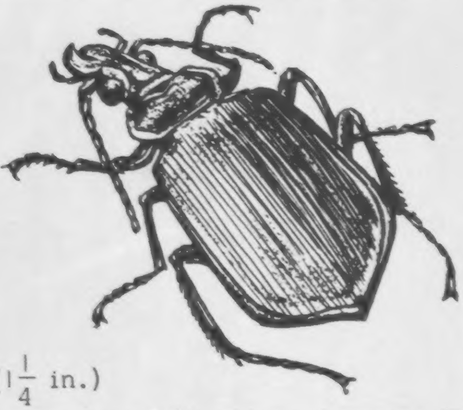
INSECT LIFE CYCLES

Egg	Larva	Pupa	Adult
Golden-eye Lacewing  (stalk $\frac{1}{4}$ in.)	 ($\frac{3}{16}$ in.)	 ($\frac{1}{6}$ in.)	 (to $\frac{3}{4}$ in.)
Monarch Butterfly ($\frac{1}{16}$ in.)	 (to 2 in.)	 (to $1\frac{1}{4}$ in.)	 (4 in. wingspan)
Cecropia Moth  *	 (to 4 in.)	 (to $1\frac{1}{4}$ in.)	 ($5\frac{1}{2}$ in. wingspan)

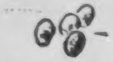
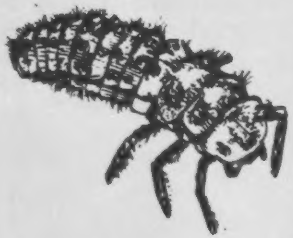
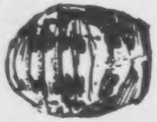
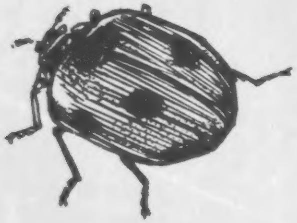
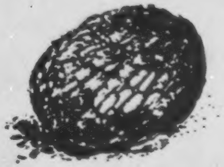
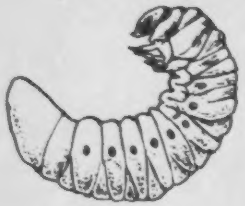
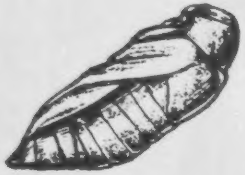
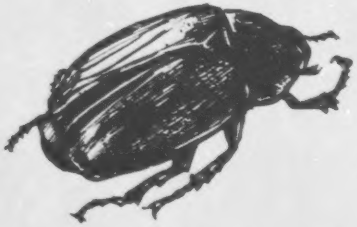
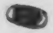
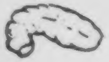
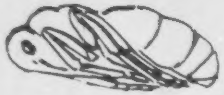
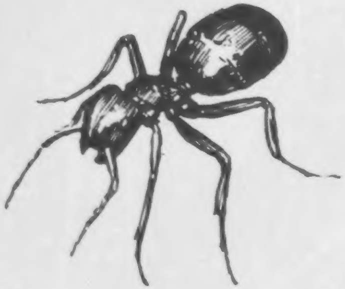
* No measurement available.

Egg	Larva	Pupa	Adult
Tent Caterpillar  (single egg $\frac{1}{25}$ in.)	 (to 2 in.)	 (to 1 in.)	 ($1\frac{1}{4}$ in. wingspan)
Woolly Bear  *	 (to 2 in.)	 (to 1 in.)	 (2 in. wingspan)
Fall Cankerworm  *	 (to $1\frac{1}{2}$ in.)	 ($\frac{1}{2}$ in.)	 ($1\frac{1}{4}$ in. wingspan)

* No measurement available.

Egg	Larva	Pupa	Adult
Mosquito  (single egg $\frac{1}{15}$ in.)	 (to $\frac{3}{10}$ in.)	 (to $\frac{1}{3}$ in.)	 ($\frac{1}{3}$ in.)
House Fly  ($\frac{1}{10}$ in.)	 ($\frac{1}{3}$ in.)	 ($\frac{1}{4}$ in.)	 ($\frac{1}{3}$ in.)
Caterpillar Hunter 	 (to 2 in.)	 (to 1 in.)	 ($1\frac{1}{4}$ in.)

* No measurement available.

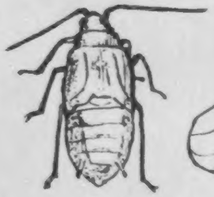
Egg	Larva	Pupa	Adult
Ladybird Beetle  *	 ($\frac{3}{8}$ in.)	 ($\frac{1}{4}$ in.)	 ($\frac{3}{8}$ in.)
June Bug  *	 ($\frac{1}{2}$ - 1 in.)	 (to 1 in.)	 (to 1 in.)
Carpenter Ant  ($\frac{1}{500}$ in.)	 (to $\frac{1}{2}$ in.)	 (to $\frac{1}{2}$ in.)	 (to $\frac{1}{2}$ in.)

* No measurement available.

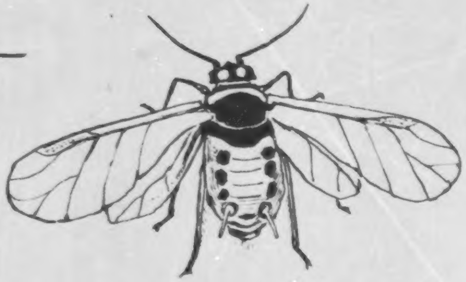
The insects on this page do not go through larval and pupal stages. The young are called nymphs. They usually resemble the adults, but are often without wings. We show nymph stages here only if they are very different from the adult forms.

LAND INSECTS

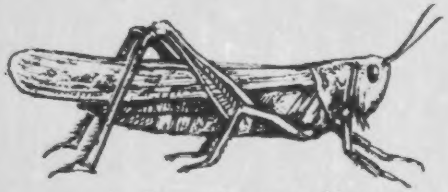
Aphid (to $\frac{1}{10}$ in.)



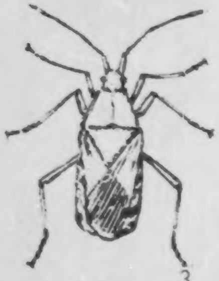
wingless female



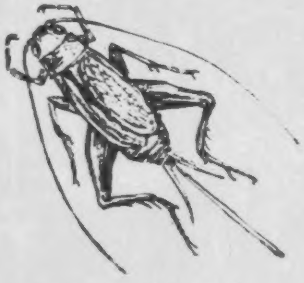
winged female



Grasshopper (2 in.)

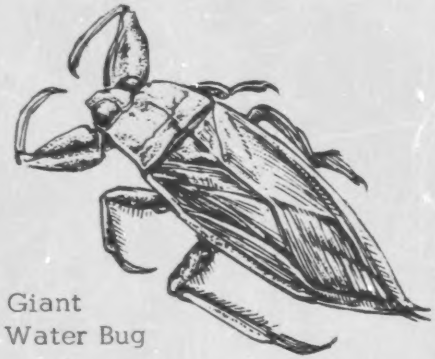


Squash Bug ($\frac{3}{4}$ in.)

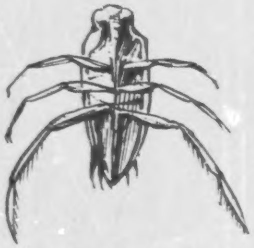


Cricket (1 in.)

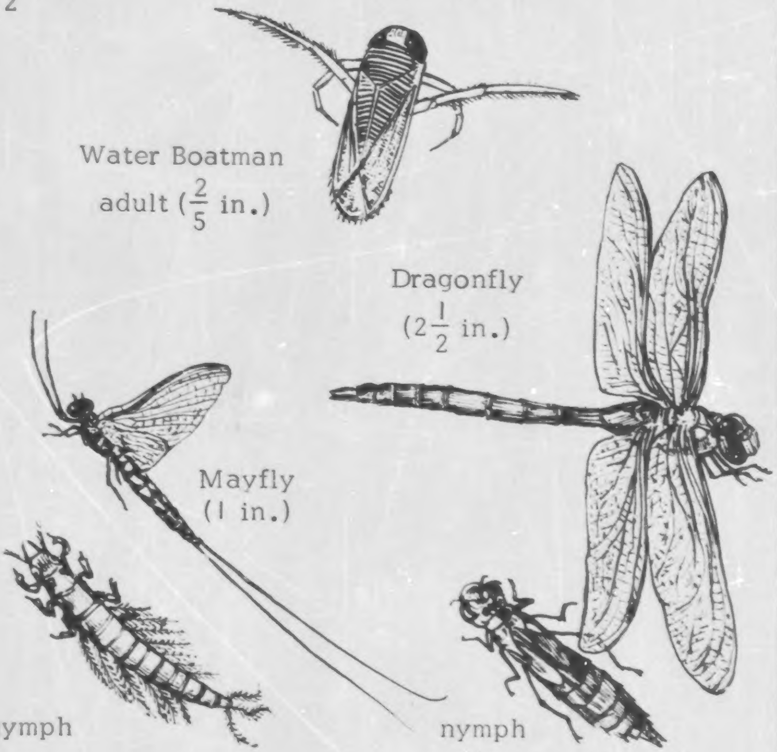
FOUND IN OR AROUND PONDS



Giant Water Bug ($2\frac{1}{2}$ in.)



Back Swimmer ($\frac{1}{2}$ in.)



Water Boatman adult ($\frac{2}{5}$ in.)

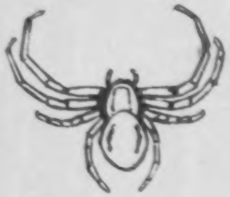
Dragonfly ($2\frac{1}{2}$ in.)

Mayfly (1 in.)

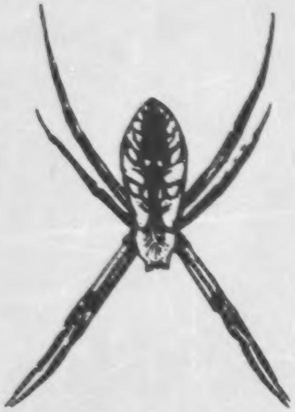
nymph

nymph

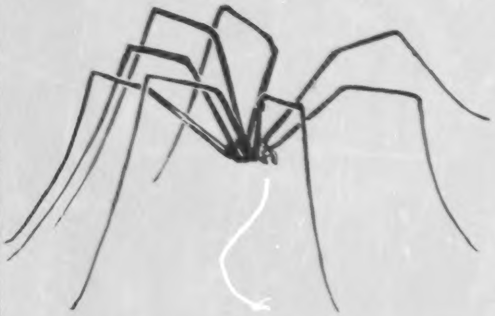
SPIDERS (WITH 8 LEGS)



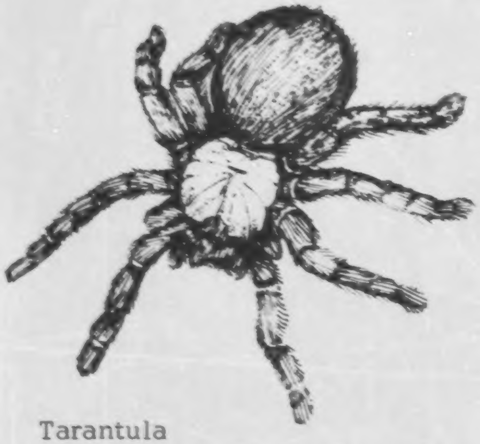
Crab Spider



Garden Spider



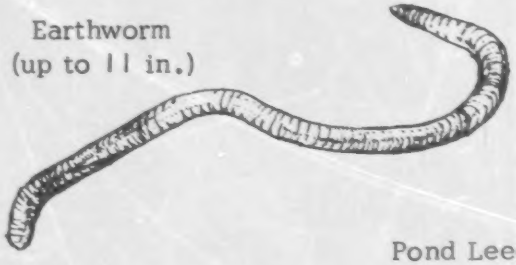
Harvestman
(Daddy Longlegs)



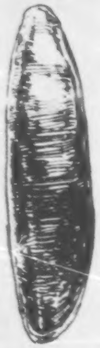
Tarantula

Spiders' scale:
life-size

WORMS AND WORM-LIKE ANIMALS

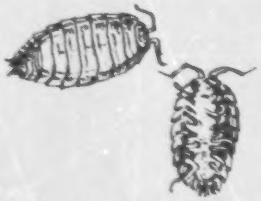


Earthworm
(up to 11 in.)

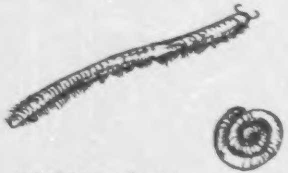


Pond Leech
($\frac{1}{2}$ to 4 in.)

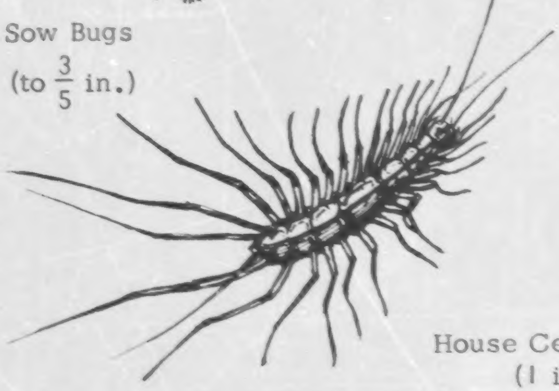
MANY-LEGGED ANIMALS



Sow Bugs
(to $\frac{3}{5}$ in.)

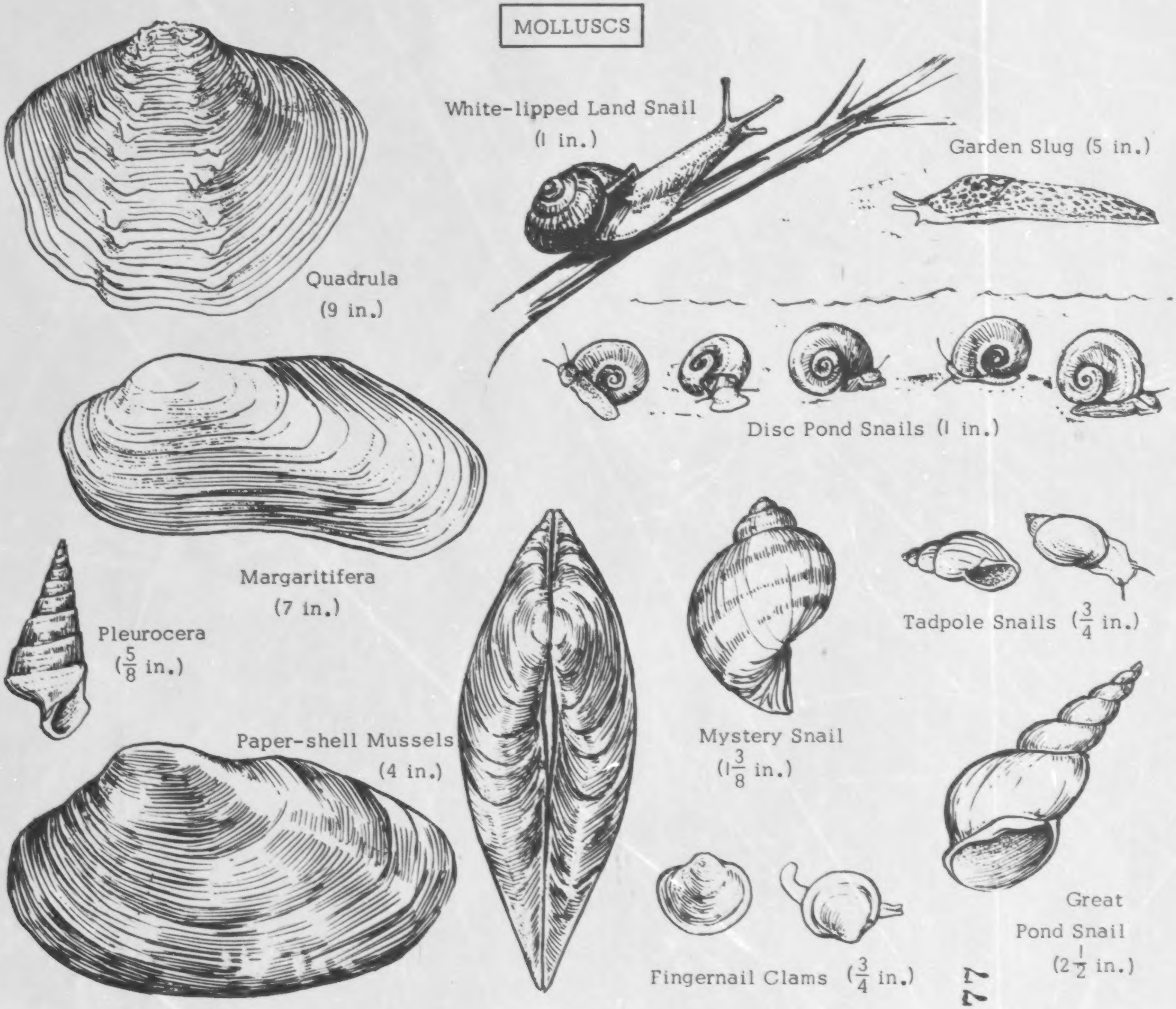


Millipedes
($\frac{1}{2}$ to 1 in.)



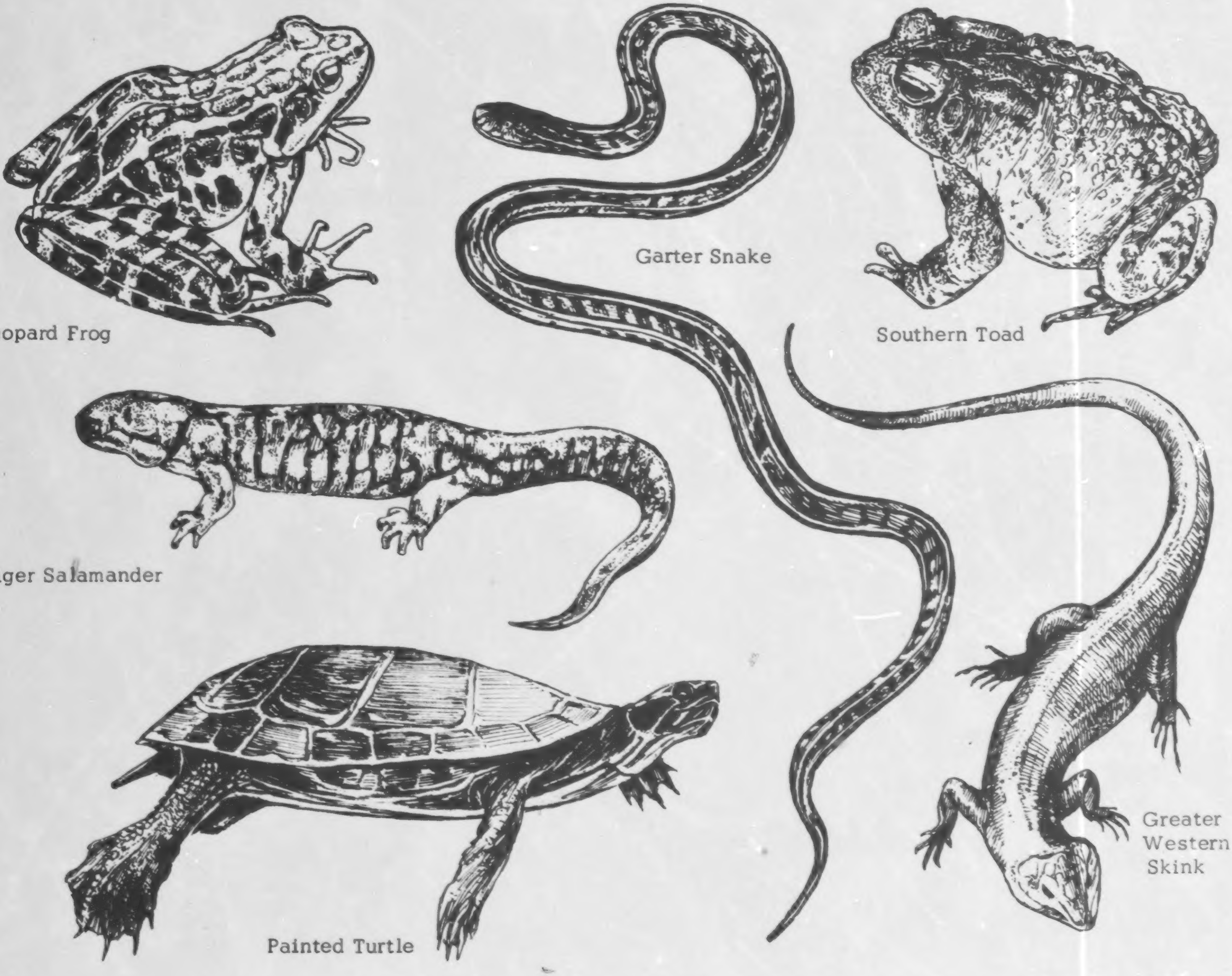
House Centipede
(1 in.)

MOLLUSCS

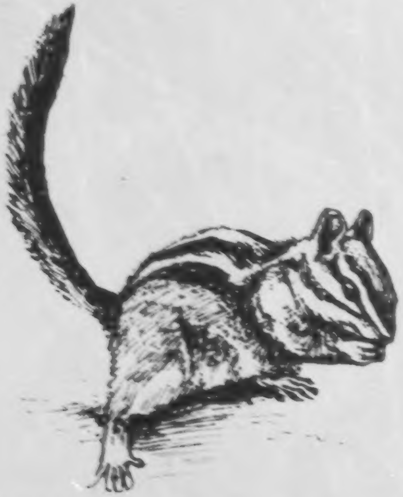

Quadrula
(9 in.)
White-lipped Land Snail
(1 in.)
Garden Slug (5 in.)
Disc Pond Snails (1 in.)
Margaritifera
(7 in.)
Pleurocera
($\frac{5}{8}$ in.)
Tadpole Snails ($\frac{3}{4}$ in.)
Mystery Snail
($1\frac{3}{8}$ in.)
Paper-shell Mussels
(4 in.)
Fingernail Clams ($\frac{3}{4}$ in.)
Great
Pond Snail
($2\frac{1}{2}$ in.)

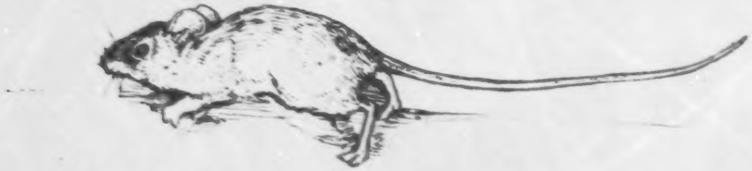
AMPHIBIANS AND REPTILES

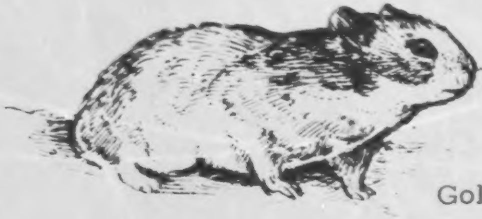
Scale : life-size

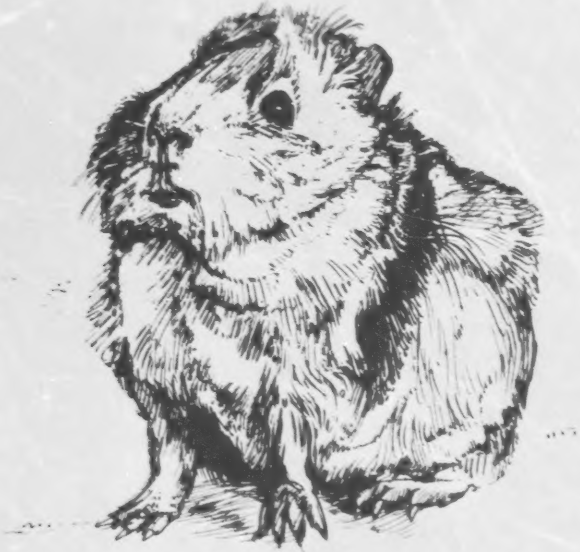

Leopard Frog
Garter Snake
Southern Toad
Tiger Salamander
Painted Turtle
Greater Western Skink

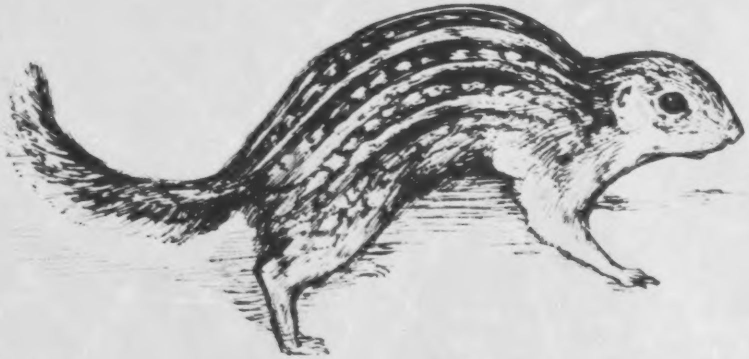
MAMMALS


San Bernardino
Chipmunk


American Harvest Mouse


Golden Hamster


Guinea Pig


Thirteen-lined Ground Squirrel

(Scale : one-half life-size)

WHEN CHILDREN BRING PLANTS INTO THE CLASSROOM

When a child brings in a plant or part of a plant, the following questions can serve as the framework of his report to the class:

WHERE WAS IT FOUND?

WHAT SORT OF PLACE WAS IT? (Sunny, shady, moist, dry.)

WERE THERE OTHER PLANTS LIKE IT IN THE SAME PLACE?

Have the children take the specimen around so that every member of the class can have a close look at it. (A magnifying glass is often helpful.) The children may be curious about what is inside a specimen. You should have a knife available to cut open fruits or to peel stems or cut across them. Ask:

WHAT DO YOU THINK THIS IS?

WHAT JOB DO YOU THINK THIS PART OF THE PLANT DOES? (Absorbs water, carries seeds, attracts insects, etc.)

Pages 74-80 contain questions pertaining to particular specimens. These questions may help you guide class discussion.

After the child has made his report and after the class has observed and discussed the specimen, you might ask:

HOW CAN WE FIND OUT MORE ABOUT OUR SPECIMEN?

The reference columns on pp. 74-80 suggest books that may help identify the specimen or give more information about it. If the specimen brought in is not included among the items listed, consult the Bibliography.

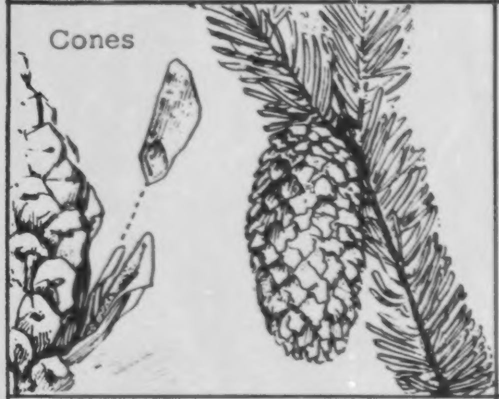
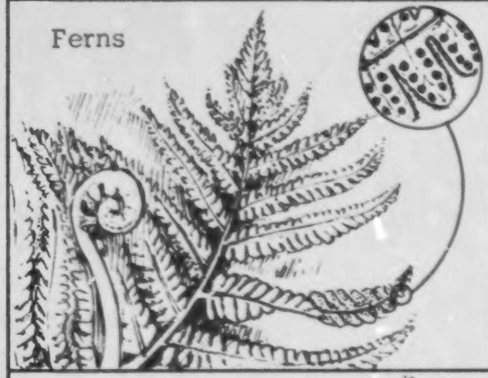
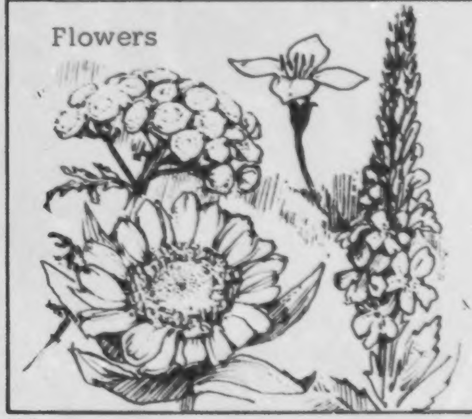
Eventually you and the class will face this problem:

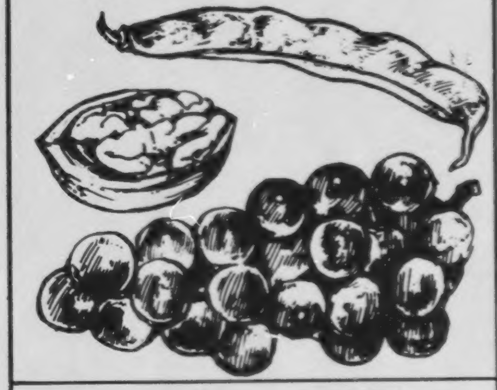
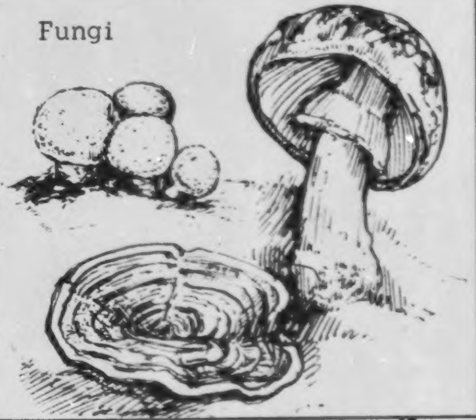
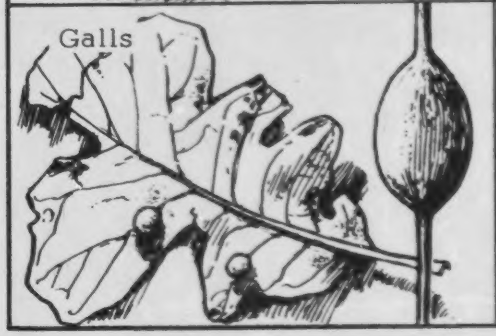
WHAT SHOULD WE DO WITH THIS SPECIMEN NOW THAT WE HAVE EXAMINED AND DISCUSSED IT?

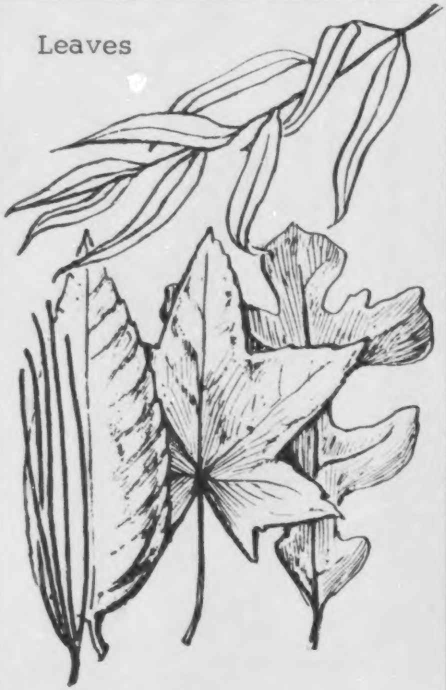
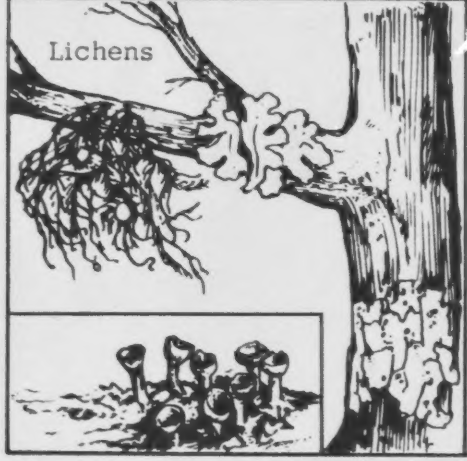
If it is in suitable condition for keeping alive, you may want to keep it in your classroom garden (p. 5). It may be a good specimen for your museum (p. 85). It may be appropriate to send it back home with the child, or it may be ready for discard.

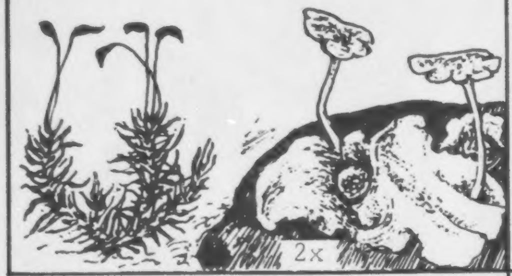
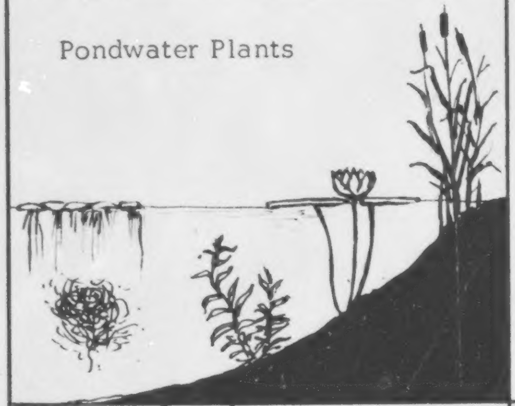
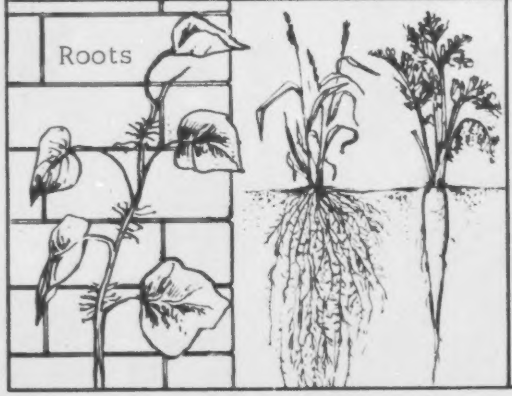
While children should be encouraged to bring things to school, they should be cautioned against indiscriminate collecting. They should always ask permission to collect from private property. They should not collect specimens in public parks. Certain plants, such as lady slippers, are protected by law and should never be picked. Others should not be collected because they are poisonous (see p. 23).

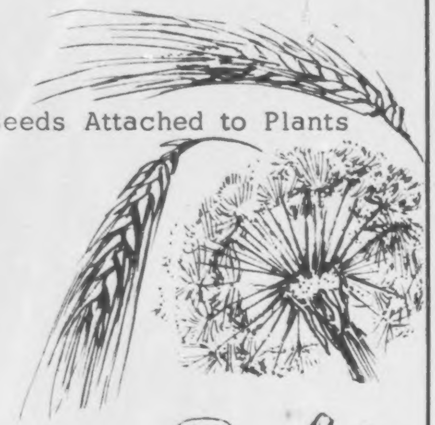
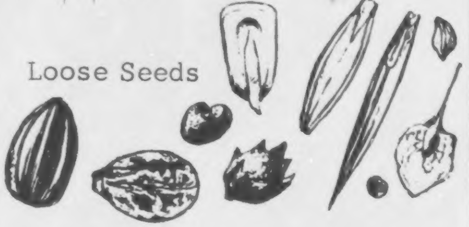
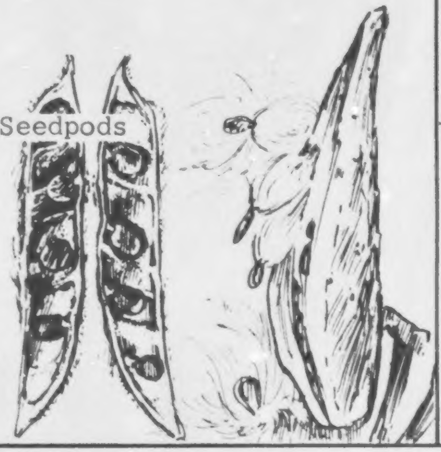
In all collecting, children should be led to form good conservation habits.

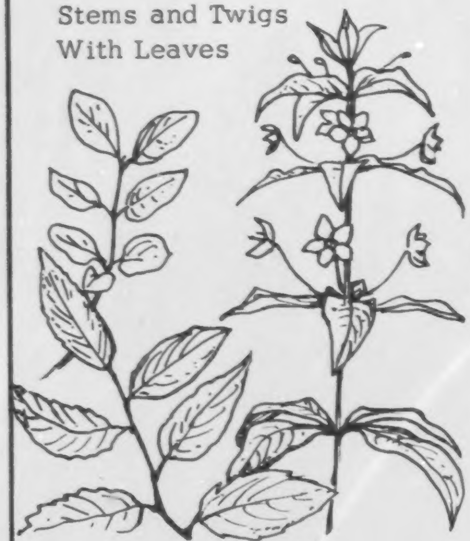
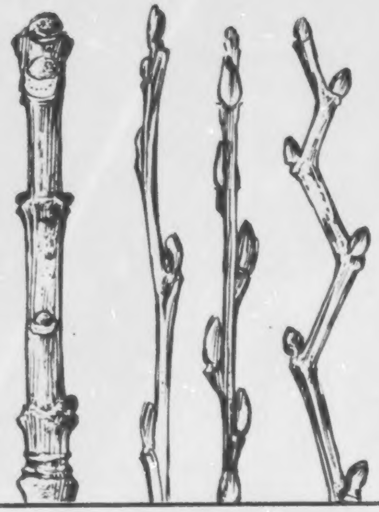
Plant or Plant Part	Questions to Guide Observation	Maintenance	References
Cones 	Where was it attached? Are there shiny lumps on it? What are they? (Resin.) Trace with your finger the pattern made by the scales. (They form a spiral.) Can you find seeds? (You can see seeds or places where seeds were on insides of scales.)	Store dry in bags or boxes.	Cormack: The First Book of Trees Zim: Trees
Ferns 	Describe the leaves. (Cut, irregular, curled, etc.) What sort of a place was it growing in? (Damp, cool, etc.) What is on the backs of the leaves? (Brown spots.) What do you think they are? (Look through a magnifier; consult a reference book.)	If fronds, put in water. If whole plant, put in terrarium.	Encyclopedia Dickinson: The First Book of Plants Sterling: The Story of Mosses, Ferns and Mushrooms Zim: Non-flowering Plants
Flowers 	Is it a single flower, a spike, a head, or a cluster of flowers? What color is the flower? Are all parts the same color? What kind of odor does it have? Do you find some yellow dust? Do you find a sticky place in the middle? Cut down the center. Do you find tiny seeds? What other parts do you find?	Make new cut across stem and place in water. If whole plant, pot or put in terrarium.	Seed or Nursery catalogues for identification. Lane: All About the Flowering World Parker: Flowers, Fruits and Seeds Zim: Flowers

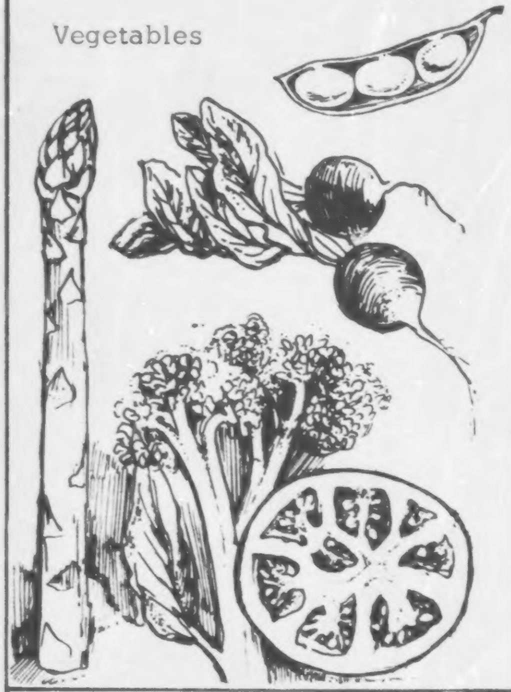
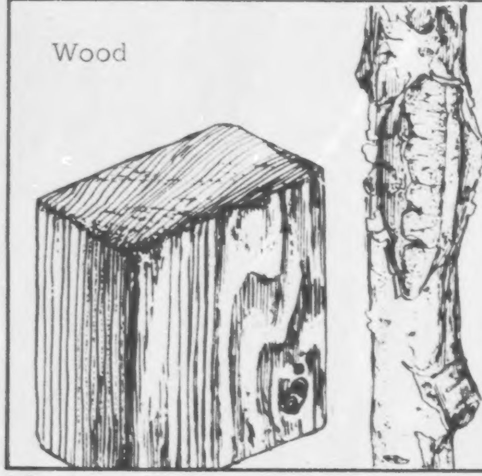
Plant or Plant Part	Questions to Guide Observation	Maintenance	References
Fruits 	What is it? (Apple, orange, etc.) How was it attached to the plant? (Look for a small stem.) What do you think a fruit is? (The part of a plant that contains the seeds. Note that this includes nuts, cereal grains, and such "vegetables" as tomatoes, squash, etc.) What is inside? How many parts can you find? (Cut it open to see skin or shell, flesh, seeds.)	Refrigerate.	Seed catalogues Fenton and Kitchen: Plants that Feed Us Selsam: Plants We Eat
Fungi 	What kind of place was it growing in? (Cool, dark, etc.) What was it growing on? What is it like inside? (Note warning on p. 24.)	Refrigerate or keep as dry specimen. If a mold, transfer to bread or fruit and keep moist and dark.	Encyclopedia Dickinson: The First Book of Plants Parker: Dependent Plants Sterling: The Story of Mosses, Ferns and Mushrooms Zim: Non-flowering Plants
Galls 	What is it attached to? Is there anything inside? (Look for larva or winged insect at very center.) Is there a hole in it? (The insect has come out.)	Keep as dry specimen.	Encyclopedia Parker: Dependent Plants Zim: Insects

Plant or Plant Part	Questions to Guide Observation	Maintenance	References
Leaves 	Is it needle-shaped or wide? Are the edges smooth or wavy? Does the leaf have lobes or points? Are there hairs on the leaf? Trace the pattern of the veins. Are there spots or holes on the leaf? What do you think made them? (Insects, disease, injury.) What tree is the leaf from? (See references.) Sometimes leaf skeletons are found. These are the woody parts of the water conducting system which appear as an intricate system of veins.	Keep in water, or Press and dry, or Iron between sheets of waxed paper. Make leaf rubbings.	Encyclopedia Zim: Trees
Lichens 	What kind of place was it growing in? (Damp, dry, shady, sunny.) What color is it? Can you see growth rings on it? Can you see little cups or disks on it? (Use a magnifier.)	Keep as dry specimen, or Put in moist terrarium. (See p. 13.)	Encyclopedia Dickinson: The First Book of Plants Parker: Dependent Plants Zim: Non-flowering Plants

Plant or Plant Part	Questions to Guide Observation	Maintenance	References
Mosses and Liverworts 	What kind of place was it growing in? (Damp, shaded, etc.) What was it growing on? (Soil, bark, rock.) How many parts can you find? (Moss: tiny leaflets and roots, capsule. Liverwort: tiny roots, green leafy structures.)	Put in a moist terrarium. (See p. 13.)	Encyclopedia Dickinson: The First Book of Plants Sterling: The Story of Mosses, Ferns and Mushrooms Zim: Non-flowering Plants
Pondwater Plants 	Look for: Tiny floating plants (duckweed; silky threads and other algae). Moss-like plants clinging to rocks and wood (algae). Rooted, leafy plants (cattails, eel-grass, water lilies). How many parts can you find on each kind of plant? If possible, look at these plants under a microscope.	Keep in an aquarium.	Morgan: The Field Book of Ponds and Streams Swain: Plants of Woodland and Wayside Zim: Pond Life
Roots 	Where do these grow? (In the soil, attached to walls, in water.) Where are they on the plant? (Attached to stems.) Are they arranged in a pattern? (No.) How long are they? (Cut and lay the pieces end to end.)	Store dry or press.	Dickinson: First Book of Plants Selsam: Plants We Eat Swain: Plants of Woodland and Wayside Webber: Up Above and Down Below

Plant or Plant Part	Questions to Guide Observation	Maintenance	References
Seeds Seeds Attached to Plants 	Some plant parts that are technically classified as fruits are commonly called seeds and are included on this page. Are they attached in rows? (Grass, corn.) Are they attached in heads? (Dandelion, sunflower.) How are they attached? (Pull some off. Note tiny stem; look for scar.)	Store dry or press.	Seed catalogues Jordan: How a Seed Grows Parker: Flowers, Fruits, Seeds
Loose Seeds 	Do they have attached parts such as down or hooks? What color are they? Can you find patterns on them? What is their shape? What parts can you find? (Take apart to see seed coat, tiny plant, stored food.)	Store dry. To germinate, see pp. 10, 18, 22.	
Seedpods 	What shape is it? How does it open? Describe the outside color, texture, hardness. Describe the inside. What is color, texture? Are there sections? Can you tell where seeds were attached?	Store dry. Refrigerate perishable pods.	

Plant or Plant Part	Questions to Guide Observation	Maintenance	References
Stems and Twigs With Leaves 	How are the leaves arranged? (Opposite, alternate, whorled.) Detach a leaf. Look at the scar it left. Look for the bud above the scar. Also see Leaves, p. 76.	Keep fresh in water, or Press, dry, or Make rubbings or spatter prints.	Coe: The How and Why Wonder Book of Trees Cormack: The First Book of Trees Zim: Trees
Stems and Twigs Without Leaves 	What marks do you see? Are these marks in a pattern on the stem? (Opposite, alternate, whorled.) What are they? (Leaf scars.) What other marks are there? (Scratches, little pores, wrinkles.) What is at the end of the stem? (A bud.) Where else are there buds? What is inside the bud? What is under the bark?	Put in water (buds may open), or store dry.	

Plant or Plant Part	Questions to Guide Observation	Maintenance	References
Vegetables 	What part of the plant is it? ("Vegetable" is a general term including fruits, leaves, stems, roots, seeds and bulbs.) What is inside? (Slice across to see seeds, fleshy parts or water ducts.) Think of some leaves we eat. (Lettuce, cabbage, spinach.) What fruits do we usually call vegetables? (Tomatoes, peppers, cucumbers, corn, squash, etc. See Fruits, p. 75.) What seeds do we eat? (Beans, peas, nuts, etc.) Name some stems we eat. (Asparagus, celery, white potato.) What roots do we eat? (Carrots, radishes, sweet potatoes, etc.) What bulbs do we eat? (Onion.)	Refrigerate. A slice from the top of carrots, beets or radishes will sprout new leaves if set in moist sand.	Seed catalogues Fenton and Kitchen: Plants that Feed Us Selsam: Plants We Eat
Wood 	Press it with your fingernail. (Wood may be hard or soft.) Trace the pattern. Look for annual rings. Is there bark on the wood? Note color, pattern. Peel it off and see what is underneath. Does it look like wood but feel like rock? (It may be petrified wood, which is a fossil.) See if you can find wood grain or annual rings.	Keep dry.	Cormack: The First Book of Trees Webber: Thanks to Trees Zim: Trees

WHEN CHILDREN BRING IN ROCKS OR FOSSILS

A childwho brings a rock or a fossil to class shows it off proudly and is anxious to know what it is. An adult with some knowledge of the subject might tell him, "Quartz," but in naming the specimen the adult runs the risk of closing off the child's curiosity about it. It is important not to do this. The child should be stimulated to focus on the properties of the specimen, because the properties of a rock or a fossil reveal its history.

A particular set of conditions produced the specimen and made it look as it does. How can these conditions be determined? First, the properties of a rock can be observed. The place in which it was found may provide additional clues. Then imagination must be brought into play in trying to reconstruct the conditions that produced the specimen.

The following questions are for an initial discussion. Use the identification guide on the following pages to help extend observation.

WHERE DID YOU FIND YOUR SPECIMEN?
(Beach, field, bottom of a cliff, etc.)

HOW DO YOU THINK IT GOT THERE?

TELL THE CLASS WHAT YOU THINK IS ESPECIALLY INTERESTING ABOUT IT.

CAN YOU DESCRIBE YOUR SPECIMEN TO US?
(Texture and color; presence of sharp corners, speckles, layers, crystals, etc.)

A very effective way to help the child focus on properties is to have him compare his specimen with another you already have in the classroom.

Have the specimen taken around the class for everyone to see. Provide a magnifying glass. Encourage the children to speculate on what might account for each of the properties that are noted. Other questions they may ask can serve as basis for further study. For example:

IS IT VALUABLE?

WHAT ARE THE SHINY SPOTS?

HOW OLD IS IT?

WHAT IS IT USED FOR?

Have the class discuss these questions first, and then go on to a more systematic examination based on the identification guide on the following pages. Finally refer the children to books to check on their speculations. (See Bibliography.) Children are very likely to ask questions for which there are no available answers, but it can be a source of excitement rather than frustration for them to think about how much there is still to be discovered.

IDENTIFICATION GUIDE FOR ROCKS AND FOSSILS

Children should feel free to pick up a rock, to squeeze it, scratch it, try to write with it on a sidewalk, look at it under water, and (with permission) try to shatter it. (See p. 84 for precautions.) They should find how different the surfaces of breakage can look in different rocks. They should discover the different ways that different rocks sound when clicked with a fingernail or another rock. They should look and touch and test and compare freely to discover all the properties they can.

On the following pages we describe several types of rocks and the kinds of environments that produced them. The discussion is focused on easily observable properties. Traditional terminology in rock classification is intentionally omitted here. Terms such as igneous, metamorphic or sedimentary do describe the environment that produced a rock. But when a child learns first to identify observable properties and then to interpret their significance, he is equipped with a process that is more reliable than memory of terminology. Thus, the "right answer" to a question about a rock is not so important as the steps of observation, interpretation and speculation. A reference book will finally give the rock a name, but it is the child's prior observations and analysis that gives the name a meaning.

SMOOTH, ROUNDED ROCKS

These rocks have been subjected to the action of water, ice, wind, or all of these. If you watch water flowing in a brook or toward a sewer after a rain, you can see how the water lifts and carries pebbles and grains of sand, bumping one against the other in the process. Suggest that the next time the children see water carrying pebbles or grains of sand, they try to find out where the pebbles or sand came from, and where the water is taking them.

ROCKS THAT LOOK LIKE HARDENED MUD

If the rock has layers and looks like hardened mud or clay, it is probably part of what was once a muddy bottom of a lake, or the mud at the mouth of a river. The body of water has long since disappeared, and the mud has become stone.

The children should think about where the mud came from and try to imagine the result of many tons of mud piling up over many ages. Suggest to the children that the next time they see a pond or brook, or water flowing from a drain spout, they should watch how the tiny grains of mud are churned about by the water and then dropped along the bottom and sides.

SMOOTH, SHINY ROCKS

If the rock has smooth and shiny sheets or plates, it was formed deep within the earth as great pressures forced crystals flat against each other. Children can try to show you the direction of the pressures that made the crystals flat by pressing the rock with their fists.

ROCKS WITH CRYSTALS

You may recognize crystals by their regular and repeated angular forms. Have the children look for all the different crystals in their specimen and observe their shapes, colors, and sizes. More than one kind of crystal may be found in a single rock, and crystals of the same shape come in different sizes.

You can easily grow alum crystals and other crystals in the classroom. (See Heller, Geology and Earth Sciences Source Book.) You may find a recipe for rock candy in your cookbook. Rock candy is nothing more than large sugar crystals.

ROCKS MADE OF PEBBLES

If the rock looks like a mass of individual stones cemented together, it may be natural or man-made concrete. The broken pieces of sidewalk a child may bring in are man-made specimens of rock. It may not always be easy to tell if a mass of cemented pebbles of various sizes or shapes is natural or man-made.

ROCKS MADE OF SAND GRAINS

If the rock seems to be made of grains of sand it may be part of what was once a beach. After many years the sand grains were cemented into stone. Many children will have seen sand in its natural location. Have them speculate as to where the grains of sand came from and why they are found near the water.

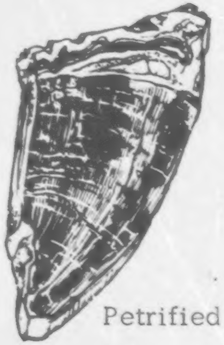
A class visit to a beach would help all the children to a better understanding of the kind of place where the specimen originated.

FOSSILS

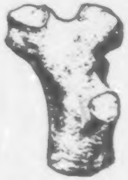
If the rock looks like a shell, leaf or animal track, it is probably a fossil. When you see a shoe print in a sidewalk, you know that a person stepped there before the concrete hardened. You can infer that the person was walking, not crawling, and that the climate or fashion required that he wear shoes of the outline you can see in the concrete. Similarly, when you see a fossil shell, bone, or egg, you know that a living thing was there before the rock hardened around the animal's track or around the plant or animal itself.

The fossil is a clue just as the shoe print is a clue. Each tells you something about the living thing that made it and about the environment. To find out what left the clue, and to learn something about its environment, you can do two things: 1) Consult the works listed in the Bibliography (p. 122), or 2) Compare the fossil with similar living animals or plants. Notice, for example, whether a similar snail lives in water or on land, or compare the shape of the fossil bone with bones that you can find at the butcher shop. Compare the shape and size of imprinted plants and plant parts with similar living things. Such comparisons can help you to make inferences about the fossil and its environment.

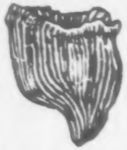
Some of the processes that preserved the living thing as a fossil can be demonstrated in the class-



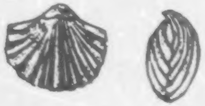
Petrified Wood



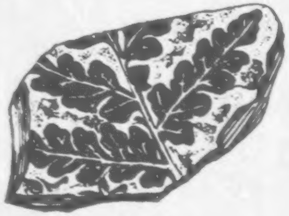
Moss Animal



Coral



Lamp Shell



Seed Fern

room. These are described in Geology and Earth Sciences Sourcebook, edited by Robert B. Heller.

ROCKS WITHOUT SPECIAL CHARACTERISTICS

If a rock has no crystals and no special color patterns or structures, if it looks glassy or greasy or nondescript, give the child a magnifying glass and have him look closely for any trace of a repeated pattern such as short ribbings or regular bumps. An obscure repeated pattern may represent crystals that have been worn smooth. If he finds nothing that remotely resembles a repeated pattern, one of two things is possible: either the crystals have been completely weathered away, or there never were any crystals.

Ask the child if he thinks the rock looks the same on the inside as it does on the outside. Then, if you trust him with a hammer, have him check his answer. (The rock should be wrapped in a piece of cloth or tough paper to prevent pieces from flying and causing injury. It should be laid on a board for hammering.) The child should think about what he finds. What makes the inside and the outside of the same rock look different?

ROCKS OF DIFFERENT SIZES

If there are two similar rocks of different sizes, ask the children how the rocks got to be the size they are. Do the children think that the smaller rock will one day grow up to look like the larger one? Will the larger rock break up to look like the smaller one? What could make a rock break?

If there are cracks in sidewalks, potholes in roads, or pebbles or boulders at the foot of a hill, children have evidence that little rocks come from big rocks. How does this happen? Have the children speculate on what makes one slab of concrete near a tree higher than another beside it. Or ask them, "How did so many pebbles come to be so close to the hole in the road? How could stones have been scattered around the hill?" Help them to see how tree roots break rocks and concrete, how moving water washes away mud or stones, and how wind picks up sand and dust. Wind, water, glaciers, plant roots, and alternate freezing and thawing, all help to break rocks and move them, causing the earth's surface to change continually.

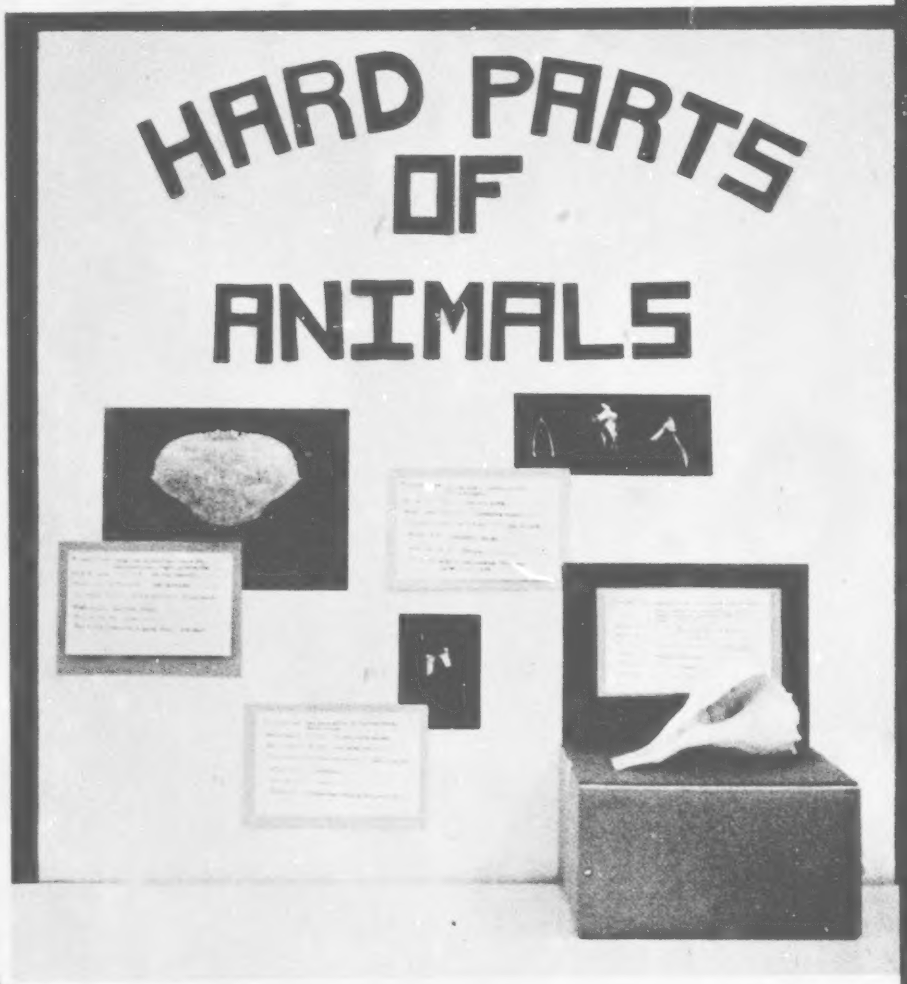
YOUR CLASSROOM MUSEUM

A museum exhibit is a special kind of display that tells a story with a group of real objects. The story lies in the relationship among the objects, and serves to clarify and enrich a topic being studied. In the approach to the classroom museum we develop in this handbook, these relationships are called themes for exhibits.

A miscellaneous collection of objects on display enables children to learn a few facts about each of the objects. But when some of these same objects are grouped with a number of others around a central idea, the children have additional opportunities for learning. In the process of grouping the objects, children are called upon to think analytically. They compare, order, generalize, etc., as they decide how objects are related and how each new object fits in with the theme of the exhibit.

For example, you might set up an acorn and the branch of an oak tree as the core of an exhibit. Suppose the class agrees that the theme of the exhibit should be "Parts of an oak tree." The children should then be urged to think about what other things they might find that are also parts of an oak tree, such as buds, bark, a block of cut wood, etc. They should then try to find examples of these objects to add to the exhibit.

Suppose for the same core objects (the acorn and the oak branch), the class agrees on a different theme, "The life cycle of an oak tree." Then they



have to think about the oak tree in a different way. In this case, additional objects that fit the exhibit include an oak seedling, oak flowers, and a photograph of a mature oak tree or forest.

This sort of involvement of the children in the setting up of exhibits increases the educational value of a classroom museum. An exhibit might begin with a single object a child brings in. In this case the class can decide on what characteristic they would like to use as the theme for an exhibit. Or an exhibit might start with more than one object, among which the children discover a relationship. In either case, once the theme has been decided on, the children should be encouraged to think about and find other things that will fit the exhibit. Everything possible should be done to make the museum a product of children working under teacher guidance, and not a product of the teacher alone.

EXHIBIT SUGGESTIONS

We give here several examples of relationships that can be themes around which objects can be grouped in an exhibit. You and your children will be able to think of many other themes, depending on what you are studying, what season of the year it is, and so on. In addition to the themes suggested below, you will find on pp. 91-93 a list of appropriate exhibit themes for each of the MINNEMAST units.

If exhibits are changed periodically, the class can have the opportunity to explore a variety of relationships.

COMMON PROPERTIES

A smooth rock, a smooth leaf and a bird's egg can be the core of an exhibit. The relationship that makes them suitable as an exhibit is their common property, smoothness. Other properties around which exhibits can be built are color (assorted red objects), a common number of parts, softness, pointedness, etc.

ORDER OR GRADATION

An exhibit can illustrate differences of gradation — for example, a series of shells ordered by size, or a group of objects ordered by texture, from smoothest to roughest.

LIFE CYCLES

Select objects that represent different stages in the life cycle of a particular plant or animal (caterpillar, chrysalis and butterfly; or seed, seedling, mature plant and dried-out plant). You might start the exhibit with an example of one of these life stages, and discuss with the children what the animal or plant would look like at other times in its life. To complete the exhibit encourage the children to look for specimens of the animal or plant in other stages of its life cycle. (You may wish to locate examples of all the life stages ahead of time to hold in reserve, so you can assist the children if they have difficulty in finding any of them.) Pictures and discussion of human life stages set an interesting background for considering life stages of other living things.

PLANT OR ANIMAL PARTS

Exhibits of parts of plants or animals can be organized in several ways. You or the children might collect leaves, twigs and bark of a particular kind of tree, or you might set up a display that enables the class to compare similar parts of different living things, such as leaves from different kinds of trees. An animal parts exhibit might show feathers from many kinds of birds, or it might include samples of the feet, skull, and teeth of a single kind of animal, together with a picture of its footprints, and a picture of the whole animal and its natural habitat.

Another type of exhibit in this category is related to social studies. You might classify as animal, vegetable or mineral the various materials used in making clothing — metal buckles; cotton, wool and nylon cloth; wooden heels on leather shoes, etc. Materials used in building a house could be classified and exhibited in the same way.

OTHER THEMES

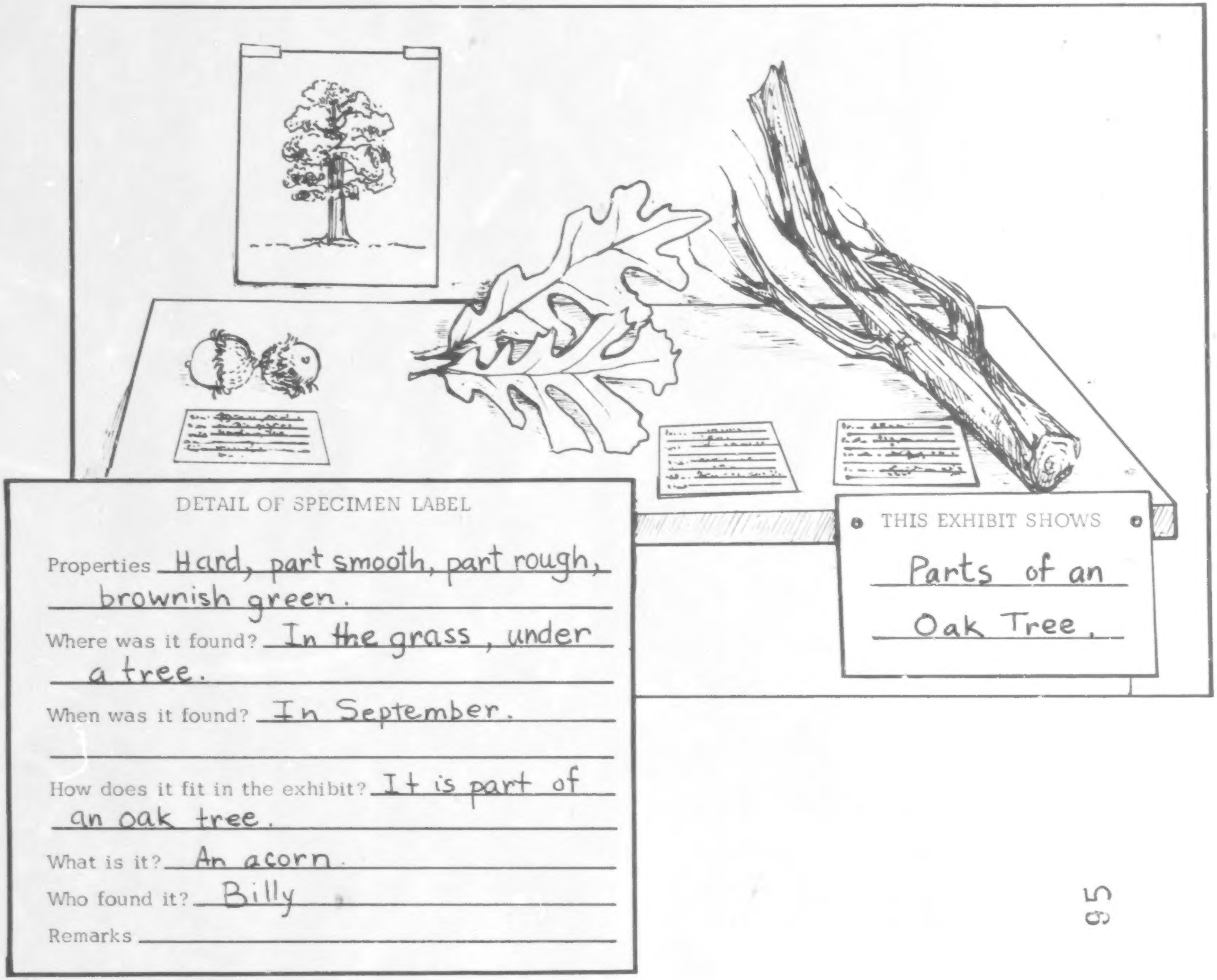
What if a child brings in an object that does not seem to relate to any of the existing exhibit themes? Be alert to his originality in reasoning. Ask him to tell you the relationship he is thinking of, and you may very well find yourself with a new theme for an exhibit. For example, suppose an exhibit built around the common property of greenness included a green rock, a green apple and a green candy ball. A child might bring in an orange and say it fits into the exhibit because all things in the exhibit are round. This may not be what you intended, but it is valid. You might let the class decide to change the basis of the exhibit to roundness, and include the orange; you might set up another exhibit of orange objects; you might develop an exhibit of round objects with subsets of different colors.

Suppose a child brings in an object that is interesting, but he and the class are unable to establish a relationship between it and the other objects already on exhibit. In this case the object can be labeled and included in a separate group of miscellaneous objects, some of which may at some future time be related to other things to make up an exhibit. In this case, of course, the "How it fits" item on the label (see p. 88) would be left blank until a theme is decided on.

SETTING UP THE EXHIBIT

The best location for an exhibit depends on the nature of the exhibit and the convenience for teaching. Exhibits may be put on display on a table, windowsill, bulletin board or counter top.

Rules for exhibits should be set by the children and teacher, according to the needs of a particular display. The children should be free to handle exhibits whenever possible. If something is perishable the class should be made aware of this, and they should share in setting up appropriate restrictions. If a specimen is brought in by a particular child, his feelings as to how it is to be treated should be respected.



DETAIL OF SPECIMEN LABEL

Properties Hard, part smooth, part rough, brownish green.

Where was it found? In the grass, under a tree.

When was it found? In September.

How does it fit in the exhibit? It is part of an oak tree.

What is it? An acorn.

Who found it? Billy

Remarks

THIS EXHIBIT SHOWS

Parts of an Oak Tree.

Exhibits should usually be made up of natural objects, but pictures can sometimes be used to enhance the exhibits. Pictures might show living things in their natural environment, or they might show stages of a life cycle that are difficult to include in their natural state.

LABELS

According to good museum procedure, you will want your exhibits to be clearly labeled. Even if the children cannot read the label, they should help supply the information you put on it.

We suggest that you reproduce standard labels. Two kinds will be needed:

1. The exhibit should be labeled according to the relationship around which it is built – for example, "Smooth things," or "The life of a butterfly."

2. Each specimen in an exhibit should also have its own label giving the information listed below.

Properties

Take the specimen around for close observation and let the children suggest what should be entered next to this question on the label.

Where was it found?

This labeled item should as far as possible relate the specimen to its natural environment. Ideally, the source of a specimen should be given as from the woods, a field, a lake, an empty lot, a construction site, etc.

Such information can help explain some of the characteristics the children will observe about specimens. For example, the difference between two plants of the same variety may be traced to the fact that one came from the middle of a field and the other came from a crack in the sidewalk. A rock found on a beach will probably look different from one found at the bottom of a cliff, and this difference also may be explained by the differences between the two environments; one rock may be rounded by the action of water, and the other may be sharp or jagged, newly broken off from a larger rock.

The height above the ground at which a specimen was found is also important. For many specimens this helps in identification or tells something about the natural habitat. For example, the location of a bird's nest helps tell what kind of bird built it. A label would specify that a specimen was found on the ground, at knee level, at shoulder level, "over my head," etc.

Objects from distant places might also be labeled with the name of the town. If the town is located on a map or globe, the children can have some sense of its distance, its climate, etc.

When was it found?

The time might be described by date, by season, by time of day or night, or whatever seems appropriate.

How does it fit in the exhibit?

This entry should be included on each label for individual specimens, as well as on the general exhibit label, because it conditions the children to focus their attention on the relationship that serves as theme for the exhibit. Before they bring a specimen in, they should have thought about how it fits.

What is it?

The chances are that some child will come up with a general name such as a leaf, a caterpillar, or a spider. To make this entry more specific, ask what kind of leaf it is. Let the children use the identification keys (pp. 63-84) and reference books to arrive at a more definite name if possible. Occasionally agreement on even a very general name for a specimen cannot be reached. In this case leave the space on the label blank until such time as the name is found.

This item is placed here, rather than first on the label, in order to help focus the children's main attention on properties and relationships. The name of the object should be looked on as useful for getting more information, but not as an end in itself.

Who found it?

The name of the child who brought the specimen in should always be mentioned. Thus the entry might read, "Polly's uncle, Mr. Tom Brown."

Remarks

This is a catch-all space in which to enter anything special about the specimen you wish to call to attention. Here are some examples: One leg was lost from this grasshopper. Is this shell an animal or the remains of an animal? Is this dandelion one flower or a group of many individual flowers?

EXHIBITS OF LIVING THINGS

Often an exhibit is set up in which something is expected to happen — a spider is expected to spin a web, a moth may emerge from a cocoon, crickets may mate, a bulb should sprout, etc. Such an exhibit requires someone to provide suitable care, such as food, water, and proper temperature. The exhibit also must be checked at proper intervals so as not to miss the event the class is waiting for.

Appoint a responsible child to be the exhibit's caretaker. Show him how to care for the living thing and tell him what to look for and how often he is to make his observations, so that he may alert you at the proper time.

MUSEUM EXHIBITS RELATED TO MINNEMAST UNITS

Below are some suggestions for developing museum exhibits related to topics in MINNEMAST units.

Unit 1: Watching and Wondering

Things we wonder about.
Things that float; things that sink.
Things collected in the grass, in the woods, in a swamp.
Things that change.
Things that live in our school yard.
Kinds of soil and rocks in our school area.

Unit 2: Curves and Shapes

Things that have curves on them (leaves, butterfly wings, some rocks).
Things with corners or points (rocks, leaves, pine cones or pine needles).
Things that are thick and things that are thin (a branch and a twig; two flat rocks).
Things that have a rectangular shape.
Things that have a triangular shape.
Things that have a circular shape.
Things that are bumpy.

Unit 3: Describing and Classifying

Leaves with toothed edges; leaves with smooth edges.
Plant parts that are green, brown, red, blue, etc.
Plants that we eat.

Unit 4: Using Our Senses

Things that are green, red, brown, etc.
Things that rattle when you shake them (leaves in a sack, seeds in a pod).
Things that have stripes; things that have spots.
Things that make sounds when you rub them (sandpaper).
Things that smell when you squeeze or rub them (onion, mint leaf, orange peel).
Things that feel rough, smooth, soft, hard, etc.
Things that have the same shape but different texture (rock and leaf, furry mitten and knit mitten.)

Units 5 and 12: Measurement

Things having about twice the area of some reference object.
Things having about twice the volume of some reference object.
Pictures of things that move quickly and things that move slowly.
Things that are three (or five, two, etc.) paper clips long.
Things ordered according to length, area, etc.
Time-ordered series of pictures showing stages in an event (e.g., seedling, large plant with bud, flower, fruit).

Units 6 and 9: Numeration

Similar things having different numbers of parts (flowers with different numbers of petals, stems with different numbers of leaves; peas in pods).
Different things having five (two, six, etc.) parts.
Things that are useful for counting or tallying (pebbles, beans, shells).
Different sets of objects with same number property.

Units 7 and 14: Symmetry

Things that show bilateral symmetry (a leaf with similar halves, a pair of clam shells).
Things that have a repeated pattern — translational symmetry.
Things that remain the same when they are turned — rotational symmetry.

Unit 8: Observing Properties

Things that exhibit any given property.
Things that have a hidden property (nuts, seed pods).
Things with properties that will change (water, living things).

Unit 9: See Unit 6.

Unit 10: Describing Locations

Interesting maps (towns, parks, nature trails).
Imaginary maps drawn to illustrate stories.
Things that show direction (signposts, weather vanes, compasses).

Units 11 and 13: Addition and Subtraction

Things from which parts can be taken away (leaves from a branch, branches or buds from a twig, peas from a pod, petals from a flower).
Things with parts that add up to a given sum (for example, two 3-leaf clover and one 5-petal flower add up to 11).

Unit 12: See Unit 5.

Unit 13: See Unit 11.

Unit 14: See Unit 7.

Unit 15: Investigating Systems

Things that can be used to connect a bulb with a battery so that the bulb lights up.
Things that roll.
Things that a magnet picks up.
Fruits with seeds.
Seeds with burrs; seeds that are airborne.
Skulls or teeth of different animals.

Unit 16: Numbers and Measuring

Things we use in measurement (rulers, tape measures, clocks, balances).

Pictures or drawings of different kinds of numerical notation (Greek, Egyptian, etc.).
Collections of different kinds of money (foreign coins, barter objects such as shells, wampum).
Different weighing devices.
Objects ordered by weight.
Moist and dried objects showing weight change.

Unit 17: Introducing Multiplication and Division

Natural objects (seeds, shells, leaves) arranged in all possible arrays for a given number.

Unit 18: Scaling and Representation

Birds' nests showing the relation of the size of each nest to the size of a particular bird.
Similar bones of different animals (wings of Cornish hen, chicken and turkey).

Unit 19: Comparing Changes

Pictures of infant and adult stages of animals.
Baby pictures of the children.
Pictures of eggs, chicks and adult birds.
Stages in a plant's life cycle.
The same variety of seeds planted at intervals.
Pictures of different kinds of time-keeping devices.

Unit 20: Using Larger Numbers

Weather station records (newspaper, class records).
Weather instruments.

Unit 21: Angles and Space

Things that have right angles (leaves on stems, legs on animals).
Things that have the property of congruence (leaves from the same plant).
Solids that have faces in the shape of triangles, quadrilaterals, etc.
Flowers whose petals form polygons with a given number of sides.

Unit 22: Parts and Pieces

Sections of fruits.
Collections of objects (leaves, rocks) divided into equivalent subsets.
Cancelled postage stamps showing equivalent values (e.g., one 6¢ stamp ≡ two 3¢ stamps).

Unit 23: Conditions Affecting Life

Kinds of animals living in different climates.
Clothing worn in different environments.
Crops grown in different climates.
Ways that plants and animals get ready for winter.
Maps of bird migration routes.

Third grade units are still under development as this handbook goes to press. We are therefore unable to make specific recommendations for exhibit themes. However, the third grade teacher should have no difficulty in devising appropriate themes after a brief study of those given here.

SECTION 5

WHEN YOU TAKE A FIELD TRIP

Field trips can be fun for both the children and the teacher. They may be as simple and easy as a ten-minute visit to the playground to investigate a specific question, or they may be longer and highly structured. In either case they are extremely valuable. Reading about living things, looking at books, films and exhibits, and even observing living things in cages, aquaria or pots in the classroom cannot take the place of observing things in their natural surroundings.

Children enjoy being taught out-of-doors, and they can learn a good deal provided that they are properly motivated, and provided that the field trips are adequately planned. This section contains many suggestions to help you get maximum benefit from your field trips with minimum effort.

We will consider three types of field trip: the excursion during which you urge very young children to "watch and wonder," the field trip designed to provide answers to specific questions, and the highly structured field trip that is an integral part of your curriculum.

WATCHING AND WONDERING

This type of loosely structured field trip is especially appropriate for kindergarteners. You and the children might explore an area to discover the surprising number of living things that can be found almost anywhere. On pages 100-113 are pictures of specific locations showing some of the things you might find, together with numerous examples of the kinds of questions you might ask — questions that are specially designed to arouse curiosity and to lead to further exploration.

THE QUESTION-ORIENTED TRIP

This type of trip may develop out of questions that arise spontaneously in class, or it may be planned in connection with a specific occasion. For example, someone might ask what ants eat, or someone might wonder how hot the sidewalk gets when the sun shines on it. The answers to such questions can be found on a field trip. If someone tells of seeing a robin on the way to school, the class might try to find out how many other kinds of birds can be seen on the school block.

Special-occasion field trips can be made on the first day of spring, after the first snowfall, on a day when you notice unusual cloud formations, etc.

We discuss question-oriented field trips extensively on the following pages.

HIGHLY STRUCTURED FIELD TRIPS

Sometimes a curriculum calls for a particular lesson to be taught outdoors. The preparation, procedures in the field, and classroom follow-up will depend on the purpose of the lesson. An example of this type of field trip can be found in MINNEMAST Unit 15 (lessons on seed dispersal systems).

A SAMPLE FIELD TRIP

The school yard is the easiest place to go on a field trip. You and the children will be surprised at how many things you will find that have gone unnoticed till then.

To motivate the journey of exploration, start with a simple question. For example, after a rain, ask the class how many things they can think of in the school yard that the rain may have changed in some way. They should think about what changes they expect, and where they would be most likely to find them.

First have the children speculate in the classroom. Then divide the class into small teams of about four. Arrange a meeting place at which the class will gather when you blow a whistle.

When you get out into the school yard, give the teams a few minutes for looking around in some of the places they thought about in the classroom. They will of course find evidence of change in many other places too.

After a while, blow your whistle for the class to assemble. Give each team a chance to tell what they have found, and then have the teams lead the rest of the class to see their discoveries. Ask questions to encourage speculation.

We give here some of the things that might be found, together with some appropriate questions.

Puddles: Why is the puddle located in that particular spot? How long will it last? Is it in the sun or shade?

Downspout and curbs: Look for washed-out areas surrounded by debris. Where did branches, leaves, sand and gravel come from? Why is the debris in the particular position that the children see? Is water still running out from the spout? Where does it come from? Where does it go? Where are the plants from which twigs and leaves were washed? How far were the twigs and leaves carried by the water?

Patterns in sand and gravel: Splash patterns, rivulets, channels, deltas and sand bars may be found, depending on how hard it rained.

Plant life: This will look clean and fresh. See if anyone recalls a day on which the plants looked wilted. Do they look wilted today? See if soil has been washed away to expose plant roots.

Earthworms: They are often all over the ground after a heavy rain. Where do they stay on dry days? Why did they come out now?

Damaged spider web: Where is the spider? Will it repair the web?

Weather: What does the sky look like today? What did it look like yesterday? Is it warmer or cooler today than yesterday?

Do not feel that you have to answer all the children's questions or that they have to answer all of yours. Encourage them to come back to the same spot another time to verify a hypothesis; show them how to look up answers to some questions.

You can keep this sort of field trip open-ended. The whole class or individual children may like to return to the same area another time to check on particular questions that interest them.

Sustained interest should be encouraged whenever possible. Several trips for one specific outdoor investigation is a better investment of time and energy than several superficial investigations of an assortment of disconnected questions. A continuing investigation helps the children learn how to follow through, evaluate their experiences, and improve their methods on the next trip.

SOME OTHER FIELD TRIP IDEAS

There are almost unlimited opportunities to observe living things in their natural environment, things as simple as a dandelion growing out of the crumbling crack in a sidewalk, or a flock of English sparrows or starlings in the school yard. The following few suggestions may help you to develop field trip ideas of your own.

Adopt a tree. Have the class visit it periodically and record observations. Observe its growth. Note seasonal changes. Draw the animals that live in the tree. Make leaf rubbings. Are the leaves the same as those on the tree next to it? How many different kinds of trees can you find in the area?

Visit a desert (a hot, dry area such as the playground) What lives in your desert? (Weeds, ants, spiders.) How hot is the ground surface in the sun? In the shade?

Examine gravel. How many kinds of stone are there? Observe their colors and other properties. Order the pieces by roughness, by size, by size of crystal.

Observe plant growth. Take a winter walk to see if anything is growing yet. Bring a branch in after the January cold has broken its dormancy. Put it in water and watch it. The buds may open. (What is inside a bud?) Aphids may appear. (Where did they come from?) When do plants start to grow outdoors? Go out again on the first spring day to see whether any plants have started to grow yet. If not, check again a week later. Do all plants start at the same time? Keep a chart showing the sizes of different plants each week.

Visit an ant hill. How high is it? How fast do the ants move? Do they move faster when there are many people around? What do ants eat? (Leave samples of different foods and see which they carry away.) How many ants go into the hole in a minute? How many come out?

PLANNING ANY TYPE OF TRIP

Some trips are more complex than others, but all require some degree of planning. Adapt what you need from this general outline.

Where to go: Of course, the first prerequisite for a site is that it provide what you want the children to see or do. The closer it is and the easier it is to get to, the better. Is there room for your thirty active children? Are there problems of access? Will the children be able to see? You should obtain permission in advance if you plan to bring your class into a private area.

What to look for: You should know what you want the children to look for before you start out, even if it is stated in only the most general terms. See the suggested field trip ideas above, and study the pictures of living things in various locations (pp. 100-113).

Motivation: Discuss the purpose of the trip with the class beforehand. If the children don't know what to look for they will become bored and restless quickly. If they are absorbed in a problem they may maintain interest for a long time.

Pre-trip: Visit the site yourself first in order to have the best control of the situation and anticipate some of the difficulties or questions that could arise. Examine the area carefully. This one step can make the difference between a successful and a chaotic trip.

Materials: Take as little as possible along with you. What you decide to take depends on the purpose of the trip. You may want the children to have pencils and notepads. Pieces of yarn can serve as markers for interesting discoveries. Magnifiers might be very useful, but you risk loss. If you want to have them along, take as few as you can and put each one in the specific care of a responsible child. If you intend to collect specimens (see below), you will need appropriate equipment such as plastic bags, etc. You may also want to carry a camera.

Rules: Before the trip, have the children join you in deciding on a set of rules. Try to keep the rules "do" rather than "do not." They should include most of the following:

1. Always keep the teacher in sight.

2. Try to leave the place as you find it. Replace anything you move. Avoid stepping on plants whenever possible.

3. Be quiet and move slowly so that you do not disturb the creatures that live there.

4. When you find something interesting, tie a piece of yarn near it to help you find it again when you want to show it to the rest of the class.

5. When you hear the whistle, gather around the teacher.

Precautions: If you teach in an area where there are poisonous snakes or insects, be sure that the children know how to recognize the poisonous species. They should also be warned that they are to avoid picking up any animal about which they are in doubt.

Collecting specimens: The field trip may lay the groundwork for activities you will want to do in the classroom. Collect only such things as are absolutely necessary for such follow-up, because it is important that the children learn good conservation habits. The basic rule is to leave a natural habitat undisturbed. If an animal is caught and observed, it should then be put back where it was found — allowed to "go home." The field trip should be distinguished from a collecting expedition, which would be better carried out by you alone or with a few selected children. Plant collection is discussed on p. 23, and animal collection on p. 39.

ENCOURAGING CURIOSITY AND INVESTIGATION

So many things that can initiate learning out-of-doors are sometimes overlooked — buds on twigs, a bird with something in its beak, an ant dragging a caterpillar along the ground, the direction in which dandelion fluff is blowing, the position and phase of the daytime moon.

Any single observation can be the beginning of exciting exploration and lead to the joy of further discovery. If you become the eyes and ears of your inexperienced charges, you will soon find that your sensitized students will serve as additional eyes and ears for you. They will call to your attention things that you would ordinarily overlook.

Every observation leads to a question: What is inside buds? Why doesn't the bird swallow the worm it is carrying in its beak? Where is the ant dragging the caterpillar? What happens to the dandelion seeds after they blow away?

The most interesting questions often do not have neat, precise answers, but this should not prevent your investigating them anyway. The out-of-doors is so full of interacting things, that answers are always new and interesting and different, depending on when, where and what you are observing.

HOW TO USE THE PICTURES AND QUESTIONS

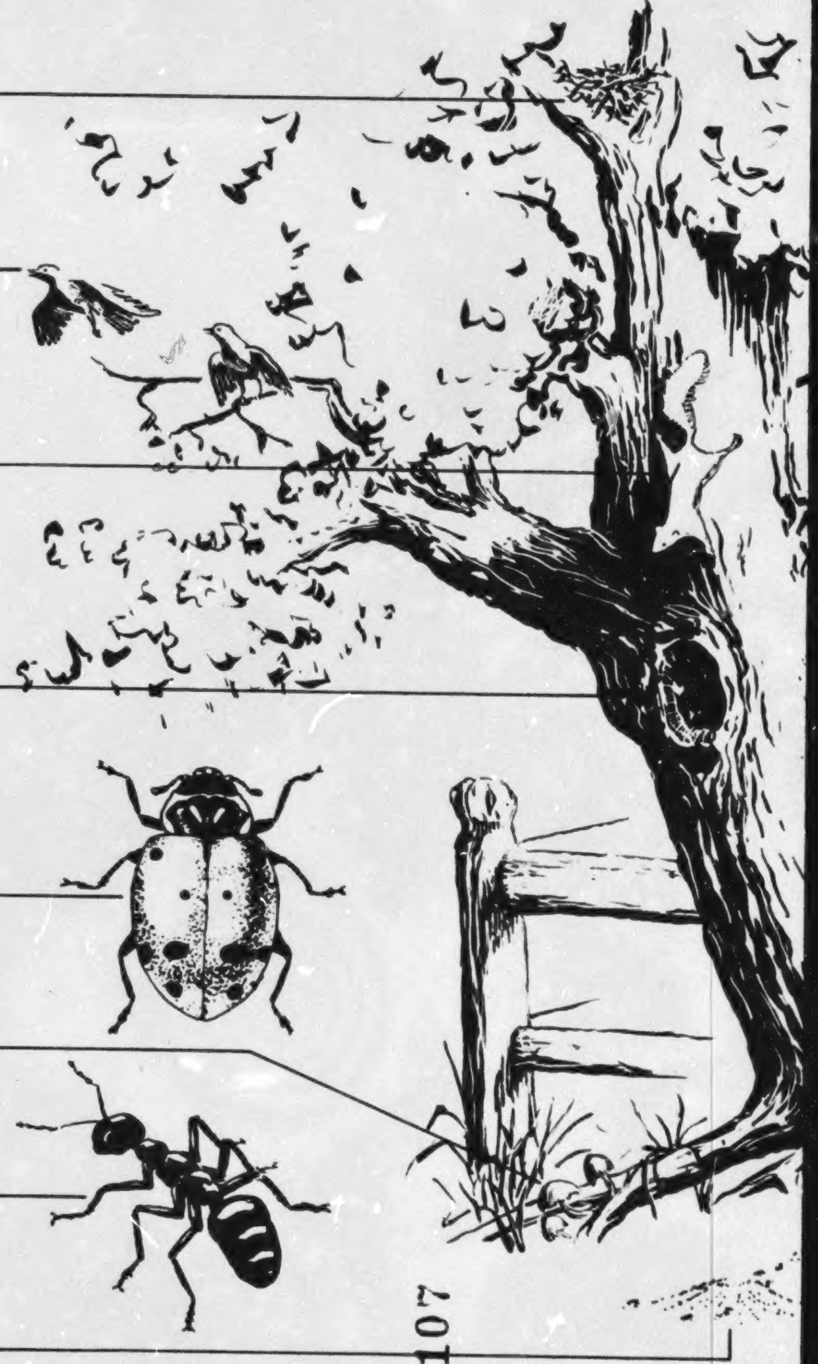
The drawings on pages 100-113 show typical places where living things can be found: (a) on and around a tree, (b) on a city street, (c) in a vacant lot or abandoned lawn or field, (d) on and under a log, stone or board that has been lying on the ground for a long time, (e) in and around a barn, (f) in and around a pond, and (g) in the school yard.

On the picture pages are suggestions for the type of questions you might ask about a plant or animal — questions that arouse and sustain curiosity and lead to further exploration.

Obviously, you will not find in one place all the living things shown in any one of the pictures, nor if you did, would you want to follow up on all of them. The chances are, though, that you will find some of them that will suit your purpose.

If you study the pictures beforehand, you can familiarize yourself with the kind of living things you might find in a prospective location, consider the type of questions that you might ask, and anticipate activities such questions might engender.

ON AND AROUND A TREE



Why is this a good place for a nest? (See what keeps the nest in place. See how the nest is hidden from enemies.)

Where is this bird flying to? (Follow it with your eyes.)

Why must this squirrel be able to walk or run up and down the tree? (See what it does when it comes down to the ground.)

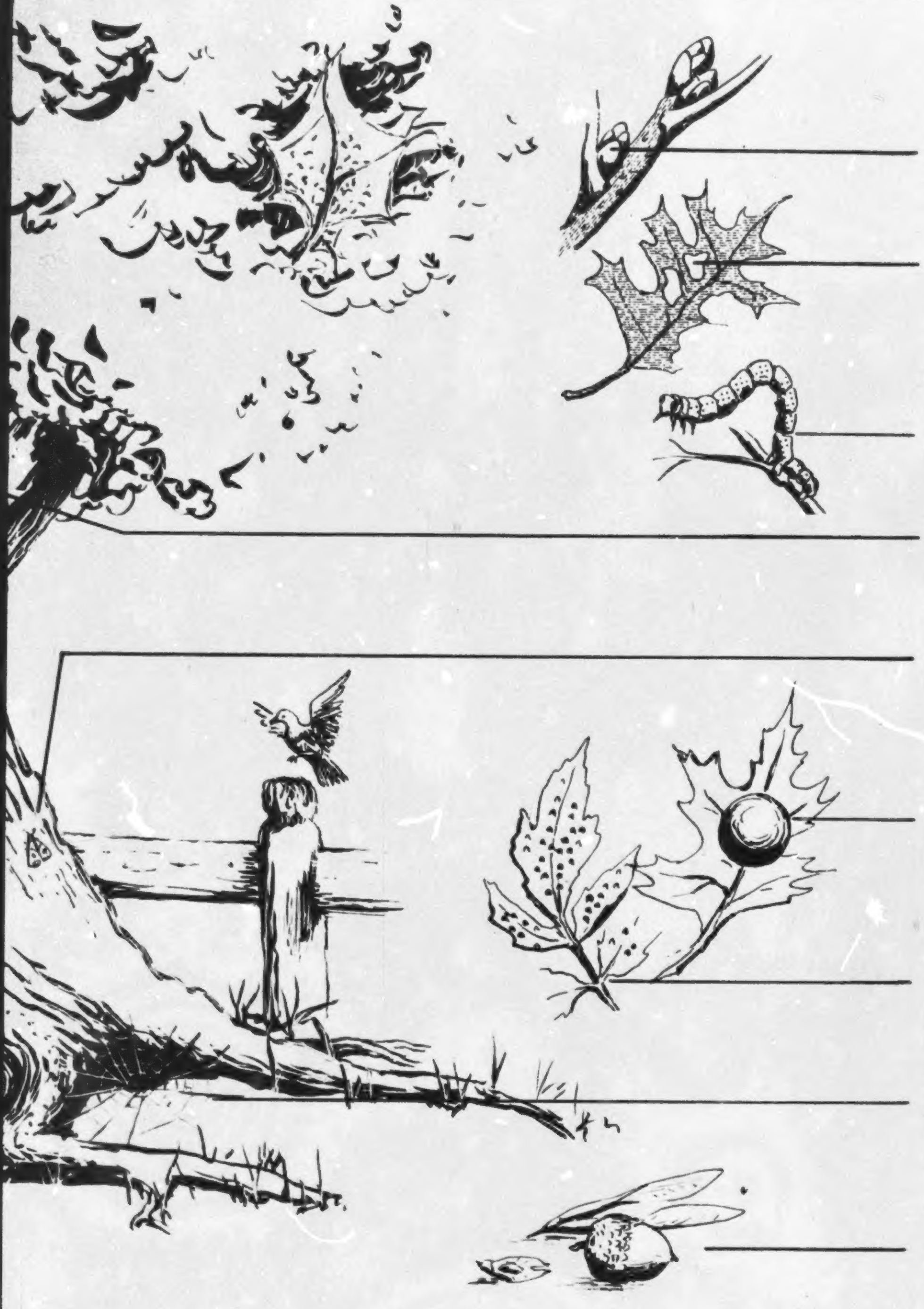
What lives in this hole? (Watch and see what goes in or comes out. If possible, look inside.)

How does this spotted beetle eat? (Look at its mouth parts.) Can it fly? (Hold it in the air on a stick and blow on it.)

Why don't these mushrooms grow just anywhere? (Dig one up with the soil. Compare the soil with soil where mushrooms do not grow.)

Where does this ant live? How does it find its way? (Follow it with your eyes. See anything on its head that moves as the ant walks along.)

How deep is this ant's nest? (Poke thin stick in it and see.)



What are these bud scales protecting? (Developing leaves or developing flowers. Place cut twig in water.)

What was eating these oak leaves? (Look for feeding insects on other leaves.)

Why is this caterpillar called an inchworm or measuring worm? (See how it "walks.")

Where are these ants going and where are they coming from? (Follow them with your eyes.)

Why is the bark probably a safe place for this moth? (See how the color of the moth compares with the color of the bark.)

What is inside this oakgall? (Cut it open to find something in it that looks like a worm.)

What is unusual about this box elder leaf? (Compare it with a healthy, uninfected leaf.)

Why is this a good place for a web? (Look for flying insects.) Where is the spider that made it? (Catch an insect and throw it into the web.)

Where did these seeds come from? (Look at nearby trees.) What is inside each? (Cut them open and look for young plants.)

ON A CITY STREET

What is the advantage of a nest so high? (Observe the cat.)

How do you know there are probably young birds in this nest? (See what mother — or father — bird is carrying.)

How do these two spider webs compare? (Observe structures.) Where are the spiders that built them? (Search.)

Is it true that a cat has ideal paws for hunting? (Examine cat's paw to see soft cushions for silent tread and sharp claws for holding prey.)

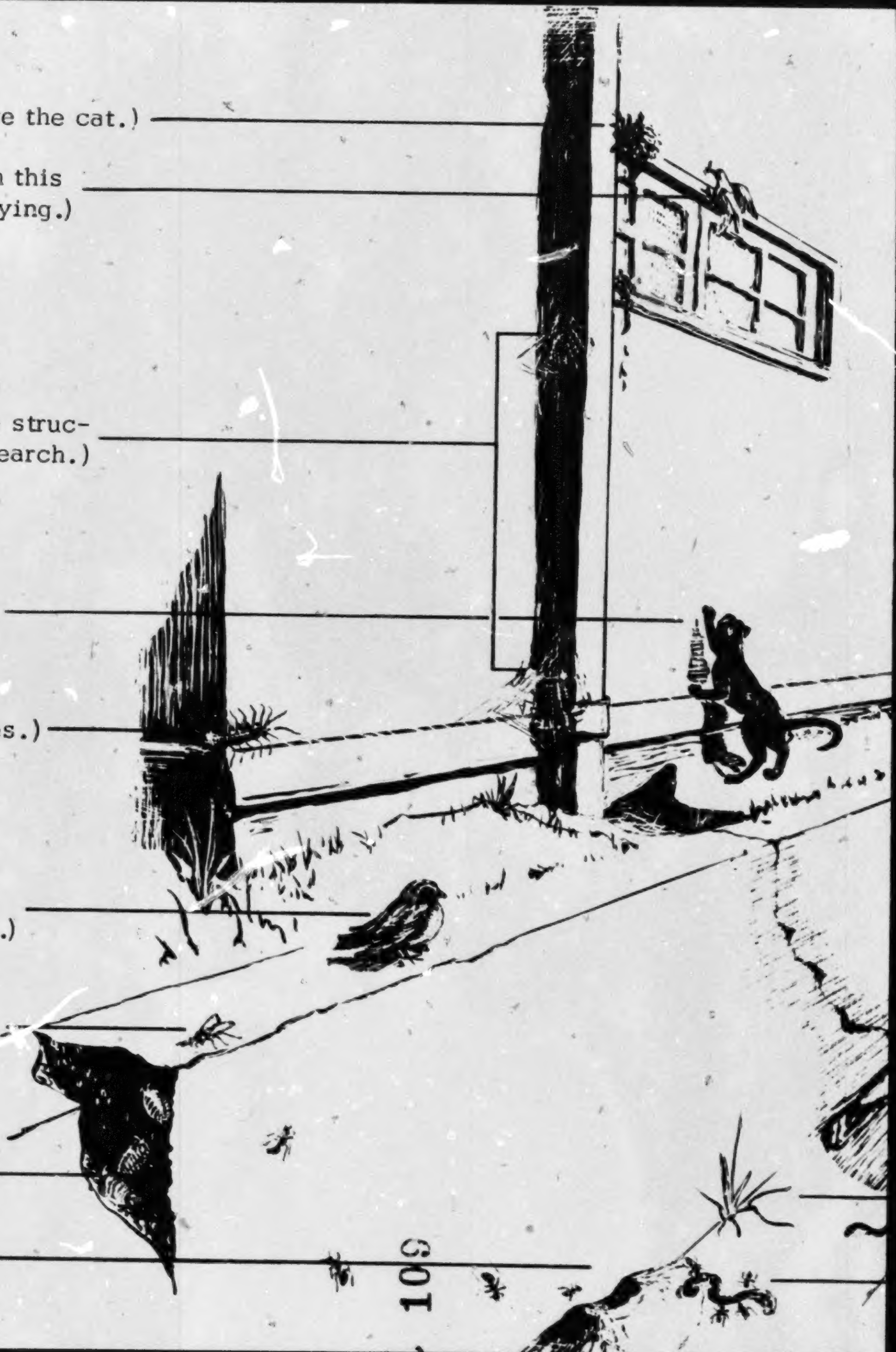
Where does this centipede live? (See where it goes.)

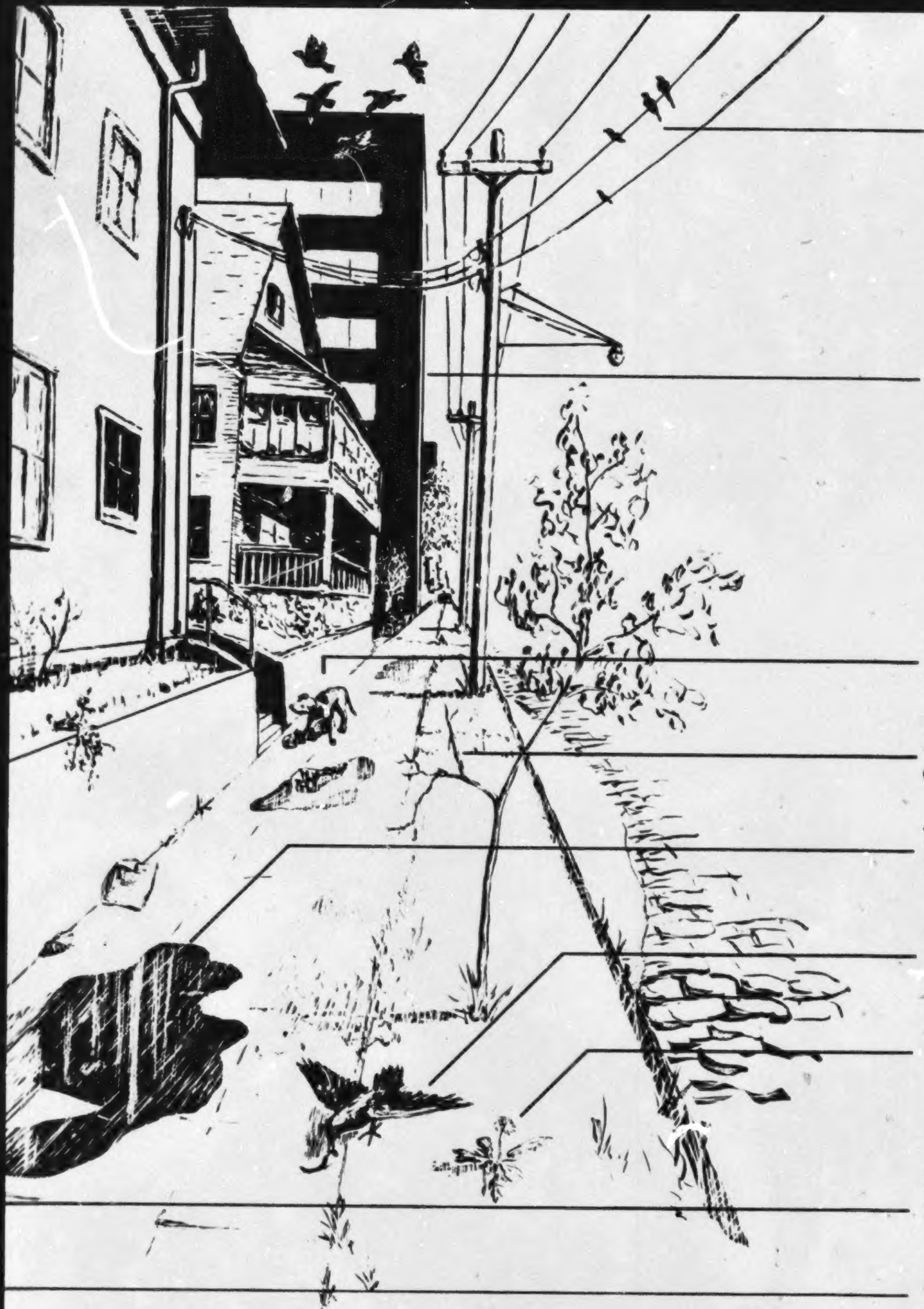
Why does this sparrow spend so much time on the ground? (Observe what it does when on the ground.)

What is this fly doing? (Observe closely and see.)

Do these sow bugs prefer to be out in the open or under something? (Place them near a log or stone on the ground and see what they do.)

Where did the ants get the sand to build this hill? (Observe ants building hill.)





What are these birds doing while sitting on the wire? (Observe closely.)

Is the side of the building warmer on the sunny side than on the shaded side? (Feel with your hand.)

On which side of the building would plants grow best? (Look to see what conditions might favor plants.)

Which of its senses does the dog use as he walks along? (Observe movements of eyes, ears, head.)

Is this tree dead or is it alive? (Examine it closely to find out.)

Where did the soil in this puddle come from? (Trace along the crack in the wall.)

What will this bird do to the worm — eat it or carry it away? (Watch and see.)

What changes will take place in this dandelion? (Examine many other dandelions.)

How do plants come to grow in cracks and in corners? (See what there is in cracks and corners.)

Are these ants fighting for the worm or are they working together? (Watch and see.)

IN A VACANT LOT

How many different kinds of living things can we find on this tree? (Look in branches for birds and nests. Examine trunk, including cracks and holes, examine region near the roots.)

Why must this bindweed wrap itself around the stem of the grass? (Unwind the plant and see whether it can stand up.)

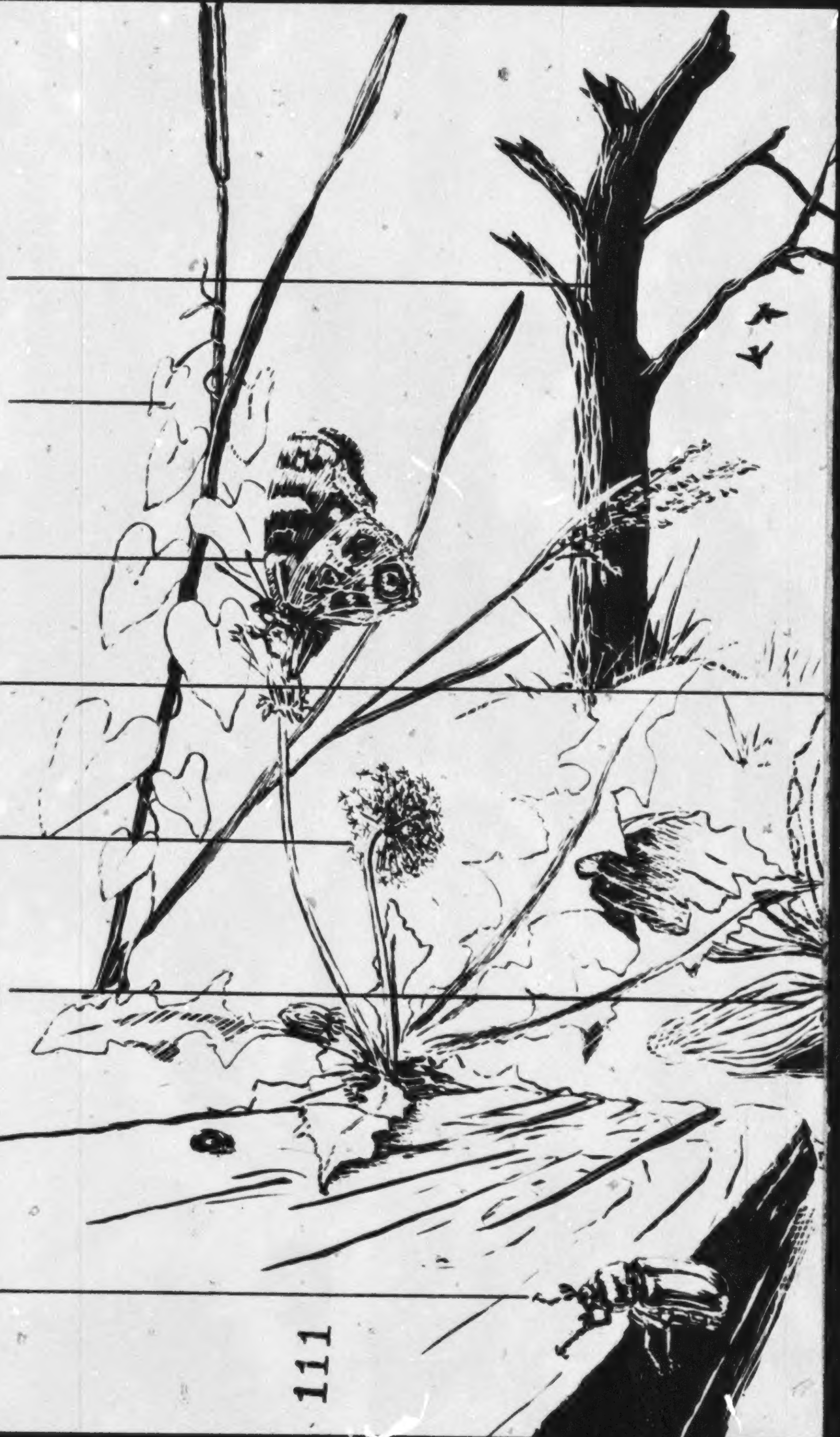
How does this butterfly reach down into the flower to suck nectar? (Catch the butterfly and use a pin to uncoil its mouthtube.)

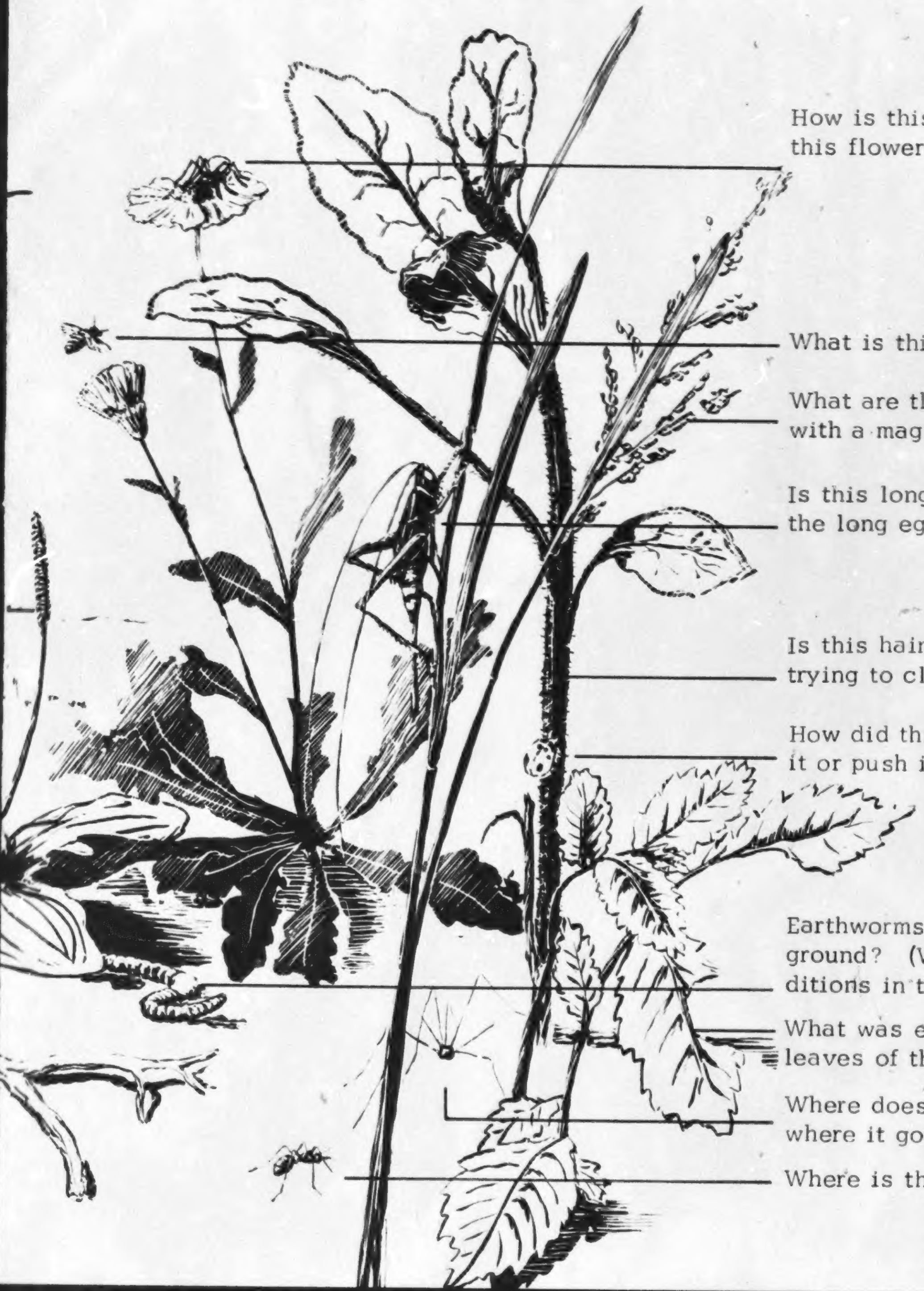
What are these little things growing on this common plantain? (Scrape them off and examine them with a magnifying glass.)

How do the little "parachutes" spread dandelion seeds? (Look at one parachute with a seed attached to it. Then blow on the ripe dandelion heads.)

How do these leaves keep other plants from growing too near this common plantain? (See how leaves block the light.)

Where does this ground beetle live? (See where it goes.)





How is this spider protected from its enemies while it is on this flower? (Compare the colors of the spider and the flowers.)

What is this bee going to do? (Watch it and see.)

What are these little things on the grass? (Look at them with a magnifying glass — also look inside them.)

Is this long horned grasshopper a male or a female? (See the long egg-laying organ at the tail end of the body.)

Is this hair of any use to the plant? (Think of an insect trying to climb up to eat the leaves.)

How did this ladybird beetle get on this plant? (Blow on it or push it and see how it flies.)

Earthworms live in the ground. Why is this one above ground? (What might have pulled it out? From what conditions in the ground might it have fled?)

What was eating this leaf? (Look for an insect eating leaves of the same plant.)

Where does this daddy longlegs live? (Watch it and see where it goes.)

Where is this ant going? (Watch it and see.)

ON OR UNDER A LOG

How does this swallow manage to change its direction so often as it flies? (Observe the motion of the wings and tail.) Why does it have to fly that way? (Guess.)

Why is this a good place for a spider web? (Look for flying insects — or for insects caught in the web.) Where is the spider that made it? (Look for it.)

What is a snail doing in a place like this? (Observe it.)

Are these mites insects? (To find out, catch one and count the legs.)

Is this daddy longlegs an insect? (Catch it and count the legs. Also, see what happens when you hold it by one leg.)

How far can this cricket jump?

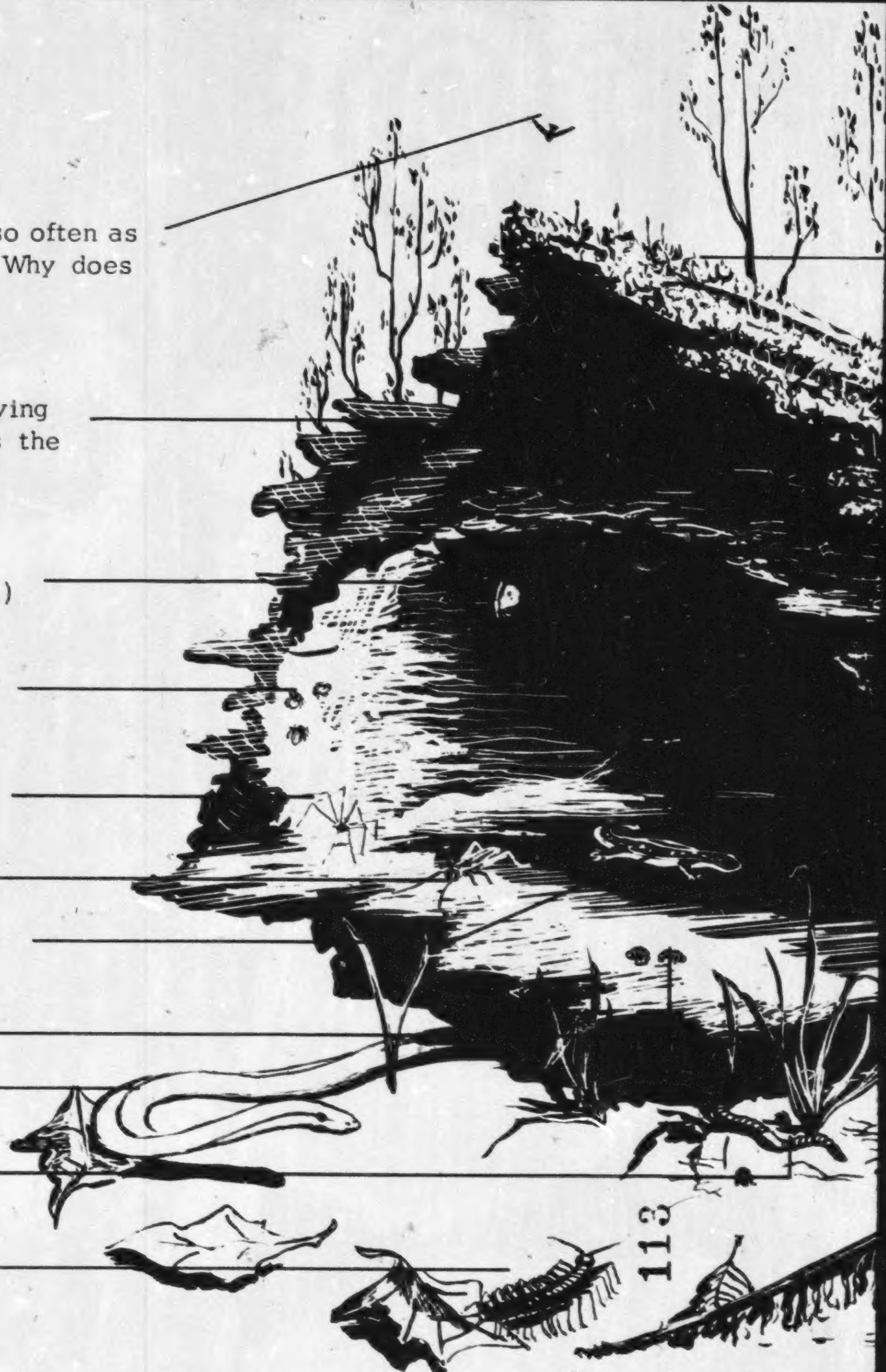
How can you account for the peculiar way this salamander walks? (Observe the position of the legs and the movements of the tail.)

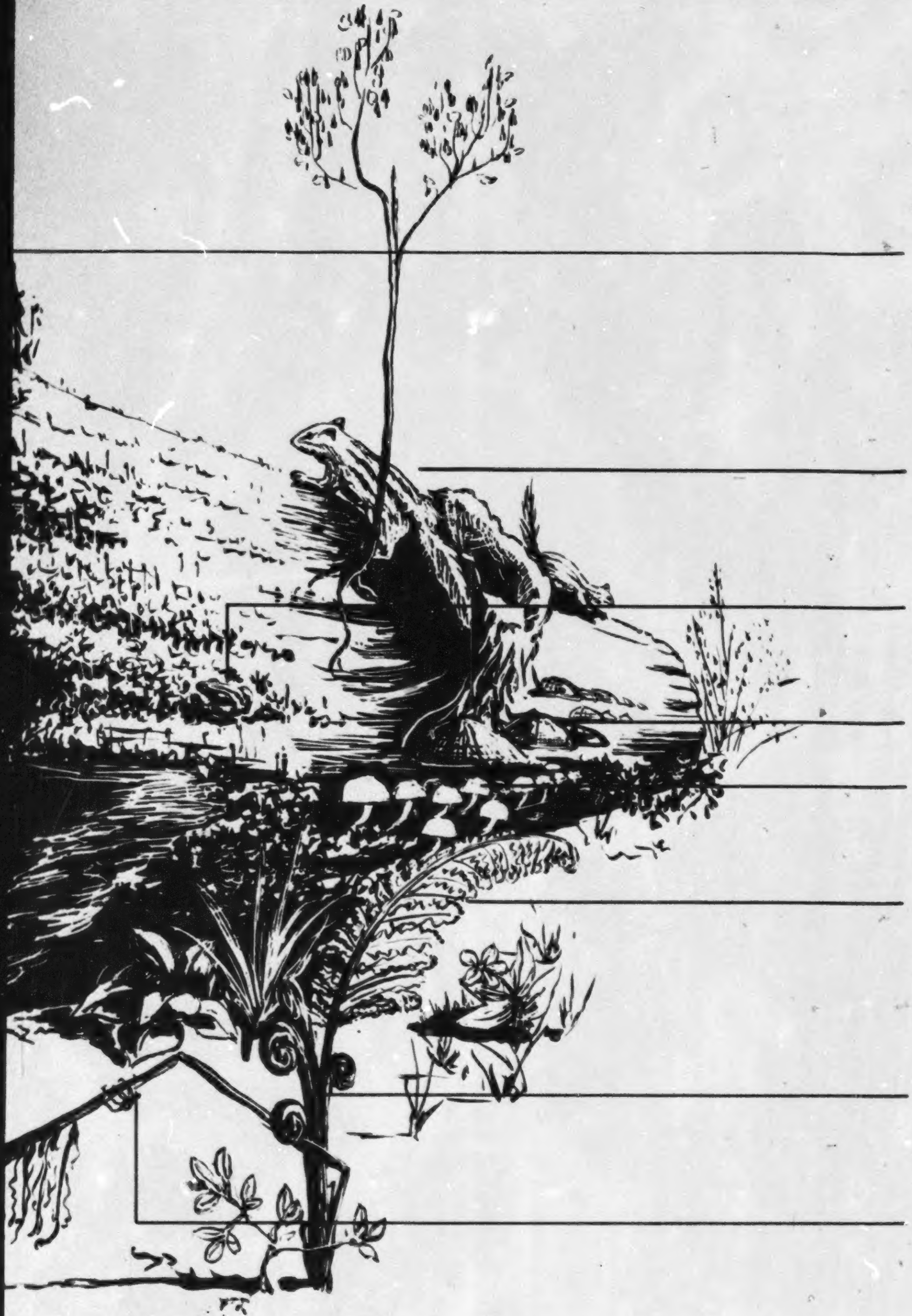
How did these baby beetles (larvae) get here?

What is this snake doing under the log?

What does this earthworm do when placed over soft moist soil? (Try it and see.)

What does this centipede do when placed near a log? (Try it and see.)





To a tiny animal this is a forest. How did this "forest" of moss come to grow here? (Find the spore cases and squeeze out the spores.)

What is this chipmunk looking for? Where does he live? (Try to find out by observing him.)

Is this a frog or a toad? (See whether he has warts on his skin.)

Most plants grow out of soil. What do these mushrooms grow out of? How do they get "planted"? (Find holes or cracks from which spores emerge.)

Ferns like this never produce seeds. How then do they begin to grow? (Look at undersides of leaves or look at special stems to find spore cases.)

Why is this called a "fiddlehead"? (Think of one part of a fiddle.) What do they become? (Unroll one and examine it closely.

What is this insect doing to the plant? (Observe it for a while and see.)

IN AND AROUND A BARN

What bird built this nest? (Wait and see which kind of bird comes to it.)

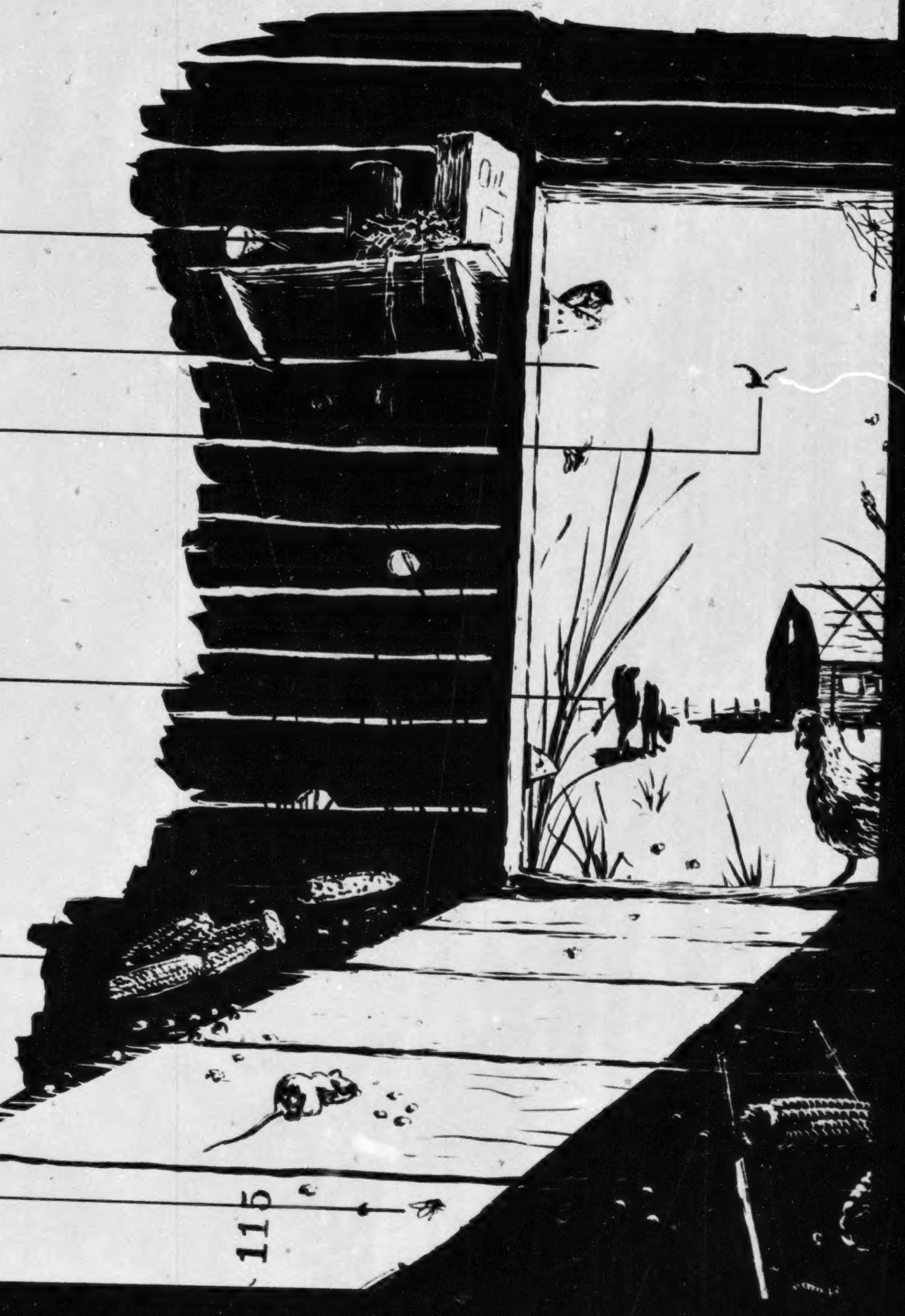
Why is this sparrow sitting near the barn? (Wait and see whether it goes into the barn and then see what it does.)

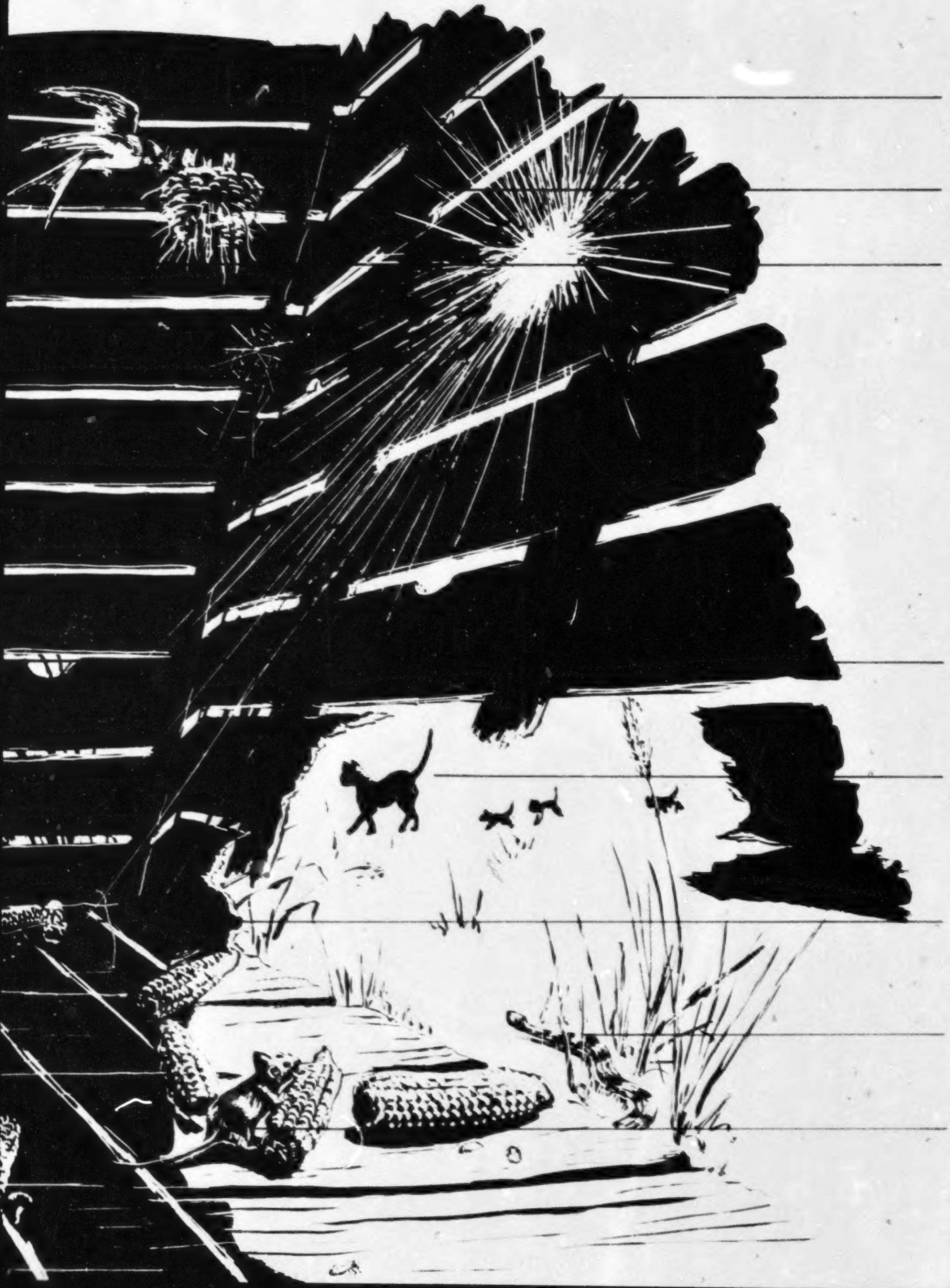
Where is this hawk flying to? (Follow it with your eyes for a while.)

What will this cow do after she has eaten a lot of grass? (Look for other cows that have already eaten and are lying down. See what they are doing.)

Why is it careless to leave corn about in a barn? (Examine the corn for insects and for evidence of the presence of rats and mice.)

What is this fly doing in the barn? (Watch it and see.)





Why is this swallow flying in and out of the barn? (See what the swallow is carrying in.)

What did the swallow have to bring into the barn to build this nest? (See what the nest is made of.)

Why is this a good place for a spider's web? (Look for insects.)

Besides corn, what else might there be in the barn for this chicken to eat? (Look for insects.)

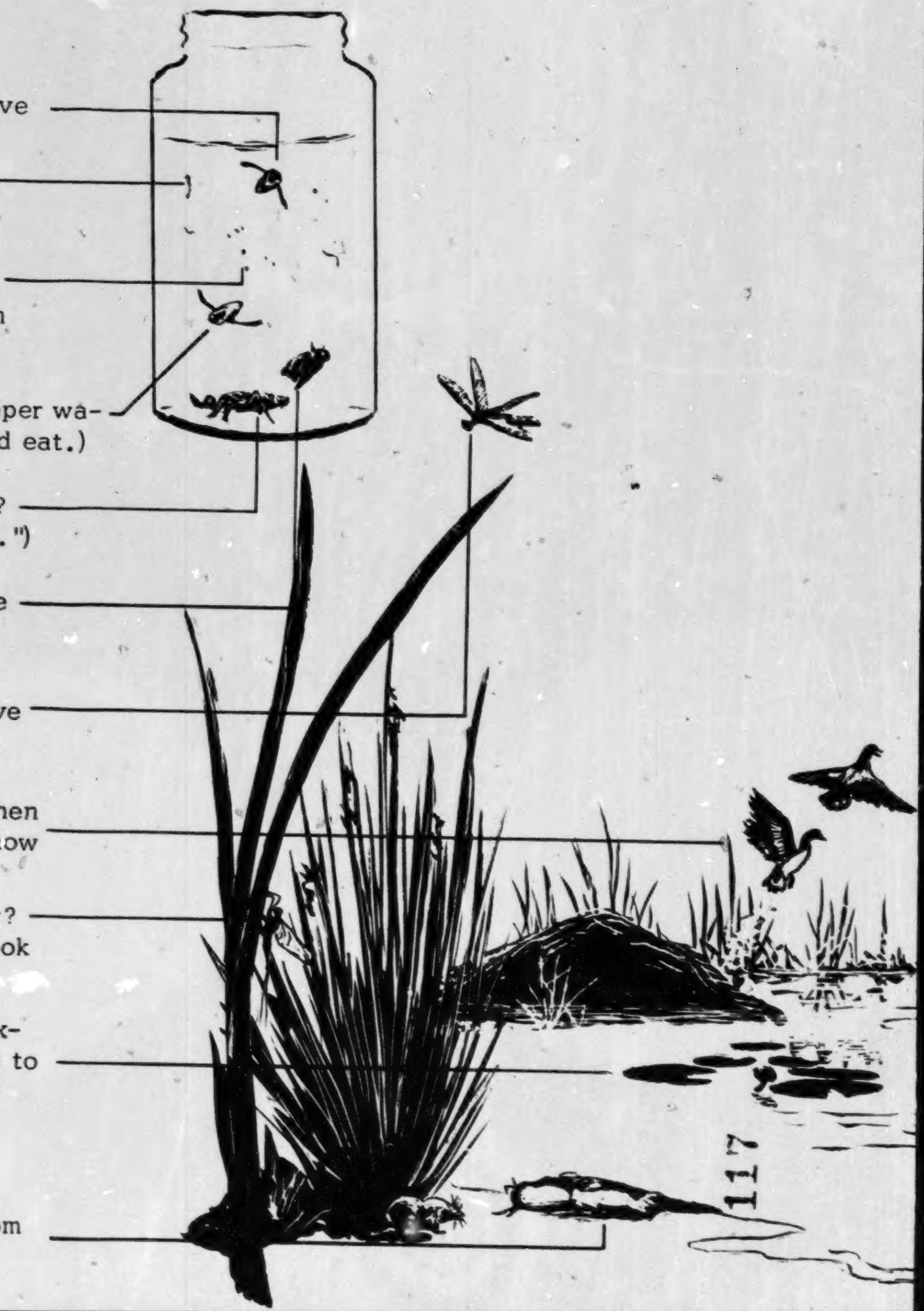
Why do cats often visit barns? (Think of at least three things there might be in a barn for a cat to eat or drink.)

Who was eating this corn? (Just guess.)

No one has ever seen this snake drink milk. Why then is it called a milk snake and why is it often found in barns? (Think of what there might be in a barn for it to eat.)

Does this mouse live in the barn or outside it? (Chase it and see where it runs.)

THE EDGE OF A POND



Why is this insect called a back swimmer? (Observe it swim.)

How does this wiggler (baby mosquito) get air to breathe? (Observe what he does.)

How can we see these little animals better? (Take them out with a medicine dropper, and observe them with a magnifying glass.)

Why does this back swimmer dive down into the deeper water? (See what is down there that he can catch and eat.)

How does this baby dragonfly (larva) catch its prey? (Use a pin to pry loose and extend its long "tongue.")

What does this snail do when he is attacked? (Poke him with a tiny stick and see what he does.)

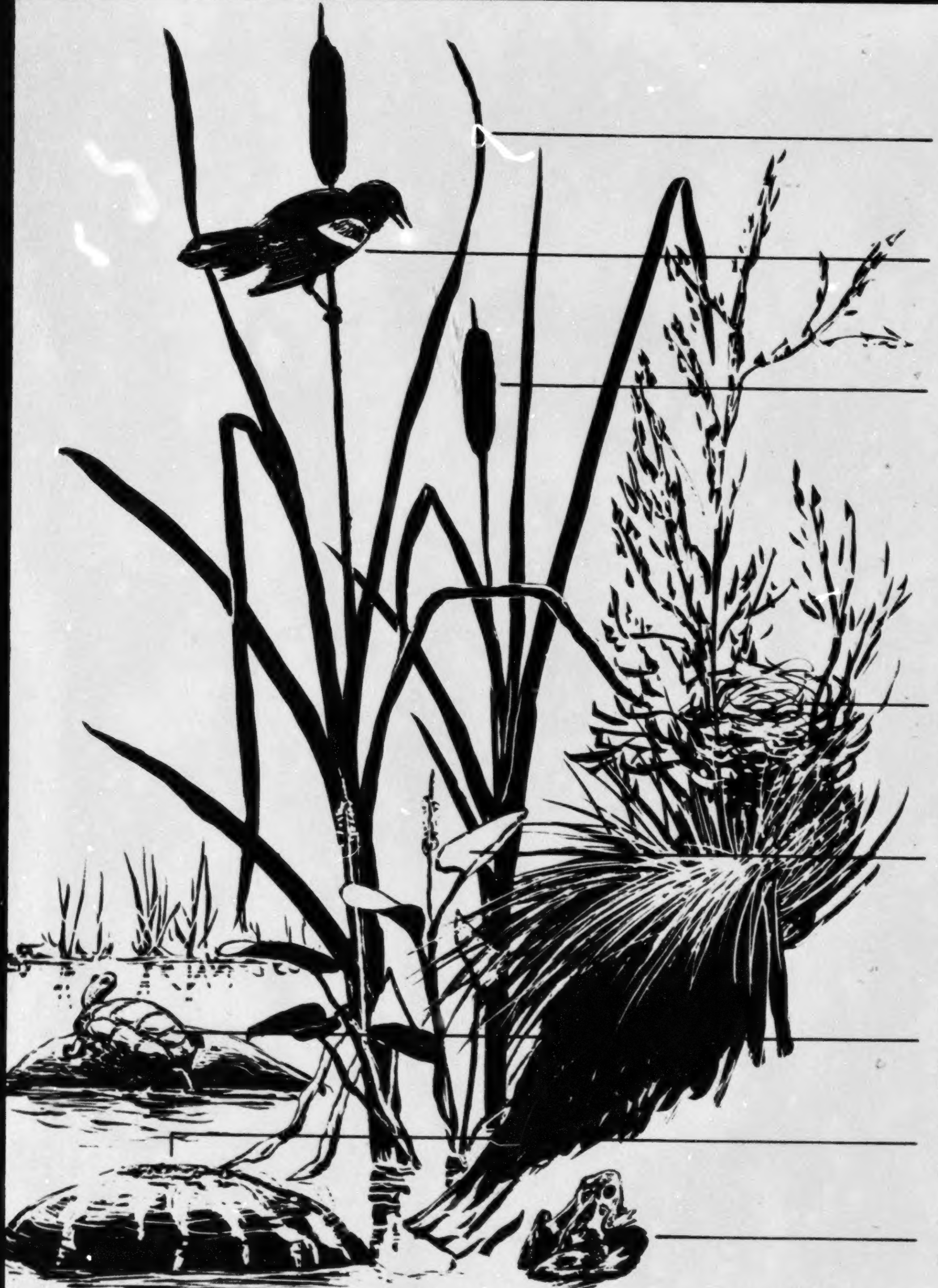
Why is this dragonfly flying over the pond? (Observe and see what it does.)

How do ducks look different from most other birds when you see them in flight? (Observe their outline and how they fly.)

How can you tell this is not a dragonfly but a mayfly? (See how its wings are folded above its back, and look at the tail end of the body.)

How do other animals make use of this water lily? (Examine top and bottom surfaces of its decaying leaves to find its seeds, which ducks eat.)

How can you tell that this bullhead lives at the bottom of the pond? (Observe the shape of its body.)



Why is this plant called a cattail plant? (Observe and feel the swelling near the top of its stem.)

Why does this red-winged blackbird keep going down among the reeds and up again? (Think of what there may be among the reeds that attracts the bird.)

What is inside this cattail? (Collect two. Cut one up to look inside. Take the other to class, keep it for several months and see what happens.)

Why is this a good place for the red-winged blackbird to have built its nest? (See how the eggs and young birds are protected against enemies that would eat them.)

What is unusual about the flowers of this pickerel weed? (Observe color, shape, etc.) What does this leaf shape remind you of?

How is being on the top of the rock different for this turtle than his being in the water ? (Think of differences in conditions — temperature, moisture, exposure.)

Who put white paint on this rock? (Observe the rock closely to see that the white is not paint.)

Where does this frog go when he is frightened or chased? (Chase him and see where he goes.)

IN A SCHOOL YARD

Why do the plants lean away from the building?
(Where does the light come from?)

Does the fence give this plant an advantage
over others of the same kind?

Why are fences put up?

How does a fence change conditions for
plants and animals?

How many kinds of animals can you find in your
school yard?

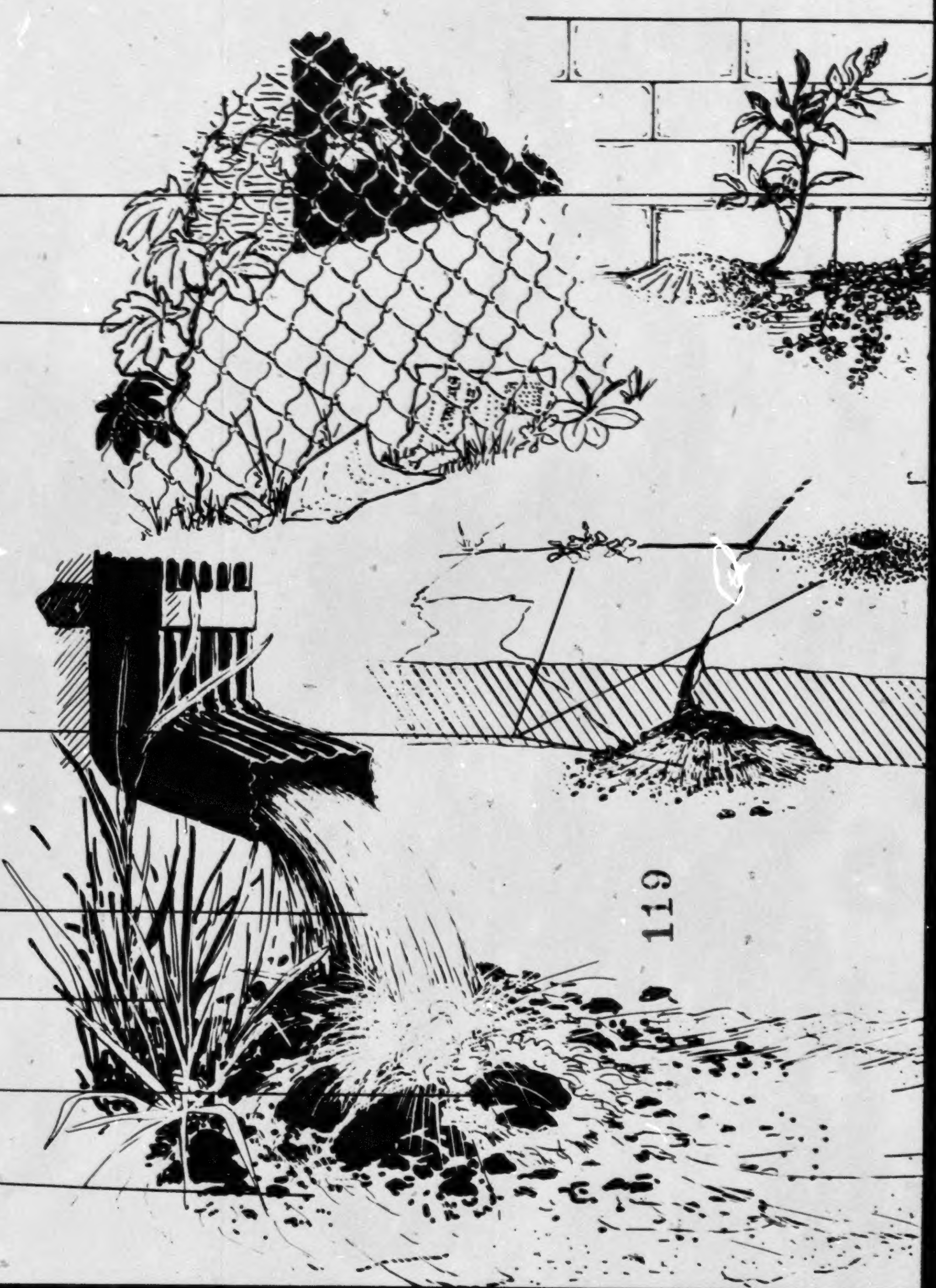
How many ways can rocks and soil be moved?
(By animals, water, plants, frost, weathering, etc.)

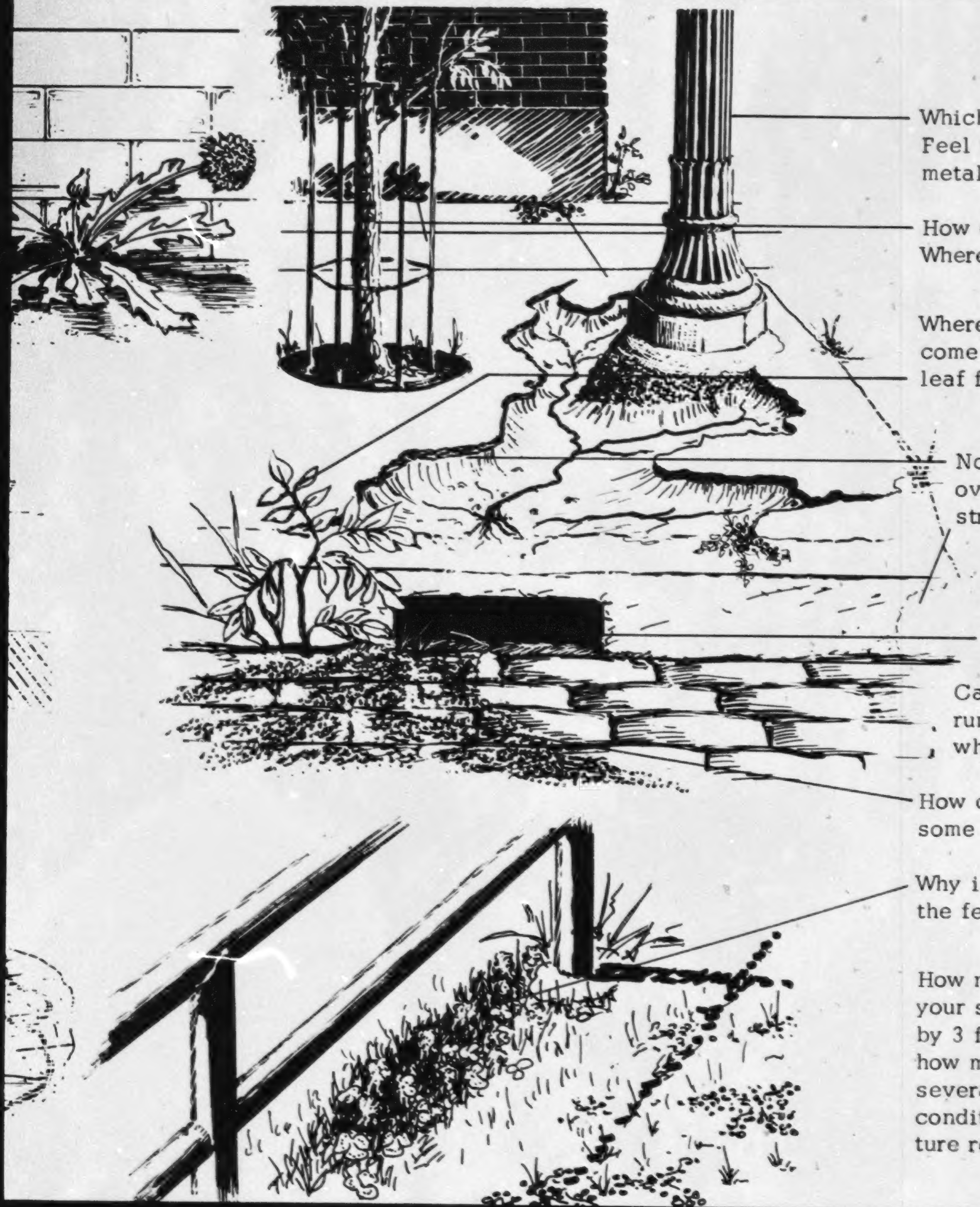
Where is the water moving fastest? Where is
the water moving slowly?

Why does the grass grow thickly here?
Why doesn't it grow below the spout?

Why were big rocks put here? (Note what water
run-off has done at the foot of the lamppost.)

Why are gravel and small rocks found further
from the spout?





Which side of the metal post is warmest? Feel the brick building. Why is the shaded metal warmer than the shaded brick?

How does this tree get enough water to grow? Where are its roots?

Where did the seed that started this tree come from? (Compare its leaf with the leaf from the larger tree nearby.)

Note the overhang caused by a hard layer overlying a soft layer. The erosion demonstrates the formation of a river valley.

Where does most of the rainwater that falls in this neighborhood go?

Can you trace the paths of the water that runs down the sewer? (Look for areas where soil has been washed away.)

How did this sand get here? (Where might some washed-away soil be dropped?)

Why is there a different plant growth under the fence? (Does the area get walked on?)

How many kinds of plants can you find in your school yard? Mark off a square, 3 feet by 3 feet. Count the kinds of plants and how many of each in the area. Do this in several places. Do you find that different conditions of light, moisture and temperature relate to different plant growth?

CALENDAR OF ACTIVITIES THROUGH THE YEAR

SEPTEMBER

Adopt a tree. Observe it periodically throughout the year (p. 97).

Collect seeds. Examine them (pp. 18, 78); plant them (pp. 18, 21); use them in a museum exhibit (pp. 91-3).

OCTOBER

Look for seasonal changes (pp. 95, 97).

Make a natural pond aquarium (p. 29).

Examine the structure of a Halloween pumpkin (pp. 75, 80). Plant the seeds (pp. 18, 22).

NOVEMBER

Collect bones of different kinds of poultry. Compare them; make museum exhibit (pp. 62, 87).

Examine fruits and vegetables associated with Thanksgiving (pp. 75, 80).

DECEMBER

Prepare museum exhibit of the different varieties of evergreens used for seasonal decorations (p. 85); compare leaf structures (p. 76).

JANUARY

Take a field trip after a snowfall. Look for animal tracks; observe patterns made by wind.

Look for abandoned birds' nests.

Observe differences among tree silhouettes.

FEBRUARY

Examine leafless twigs, observe different kinds of buds (p. 79).

Force the opening of buds indoors (pp. 23, 79, 97).

MARCH

Look for signs of spring (p. 97).

Bring a spadeful of woodland soil to put in a terrarium (p. 13).

APRIL

Take field trip in the school yard after a rain (p. 95).

Watch for emerging plants. Chart emergence and growth (p. 97).

Put newly emerged plants in terrarium and observe rapid growth indoors (p. 13).

Watch for emerging insects and note what kinds appear as spring progresses (pp. 40, 64-68).

MAY

Visit a pond (pp. 29, 77, 110).

Make a school yard field trip to observe plants and insects (see April).

JUNE

Dismantle classroom garden and zoo (p. 24). Send specimens home with children, together with suggested activities over the summer. See plant propagation (p. 19).

BIBLIOGRAPHY

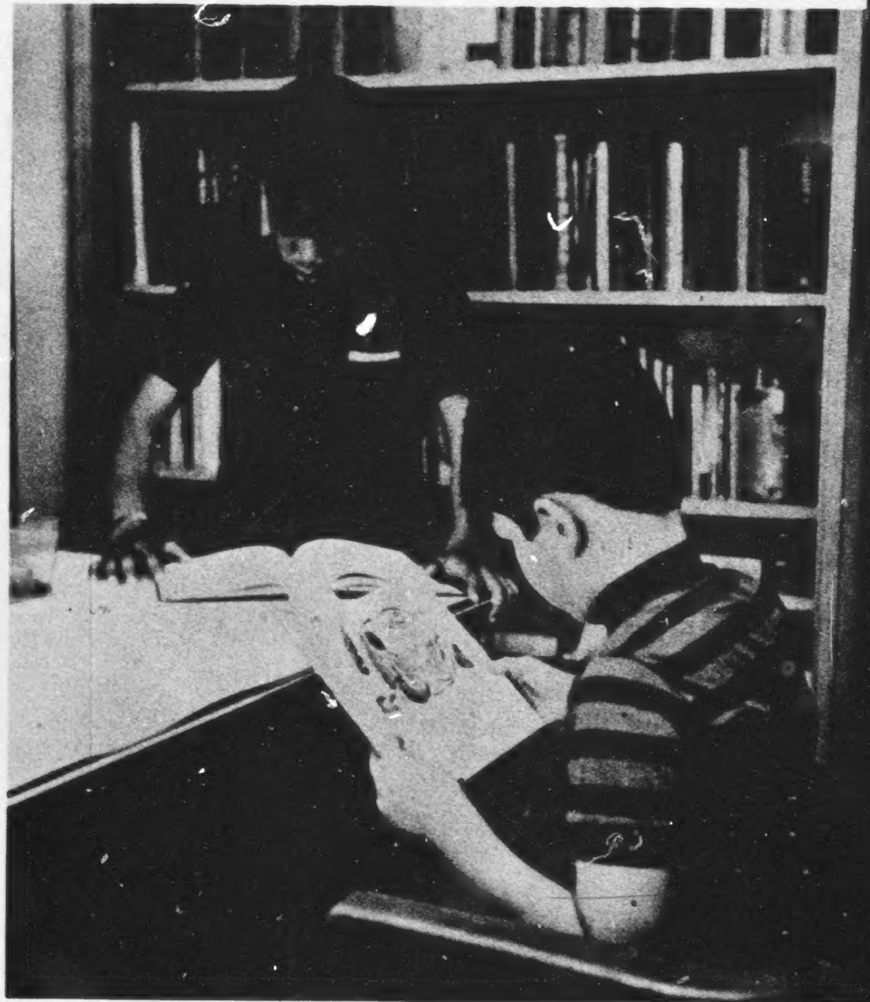
It is impossible to include in a list of this size all the valuable references that are available. We offer here some criteria as a guide for selection. You will of course be judging each book with the needs of your own class or even of a particular child in mind.

Books fill many needs. Some should supply information, others should stimulate imagination and curiosity. Fantasy should be clearly recognizable as fantasy, so as to avoid confusing the children. Facts should be well organized and stated in simple language.

Illustrations should be clear, attractive and accurate. A great deal of biological information can be conveyed through pictures, so do not select books with inappropriate or misleading illustrations. Robins should look like robins, real frogs should sit in an appropriate spot, dandelions should be recognizable as such.

Try to use books about familiar plants and animals, in order that children might make the connection between their own world and the world of books.

You will find that many of the children's books are also good sources for you. For specific information, you can always check your encyclopedia as well as specialized reference works listed below.



HOW THE BIBLIOGRAPHY IS ORGANIZED

Our first group of books is composed of sources for the teacher. These basic references should prove very valuable for plant, animal and geological information.

The second group of references is gardening magazines and catalogues. These are usually beautifully illustrated, and are very useful for identifying plants, as well as for their intended purposes of providing gardening information and telling you where you can obtain materials.

The third group of books, which comprises the bulk of our Bibliography, includes references for both teacher and child. Approximate grade level for each reference is included. The major subdivisions are further divided by type (birds, reptiles, etc.) listed in alphabetical order. Each of these includes entries for identification, activities and information.

FOR THE TEACHER

Audubon Nature Bulletins. These are well illustrated and full of practical information about plants and animals. The set of 65 bulletins is subdivided into Teaching Aids, Animals and How They Live, Insects and Spiders, Plant Identification, and Conservation of Our Natural Resources. For a list, write to the National Audubon Society, 1130 Fifth Avenue, New York, New York 10028. This organization also publishes The Curious Naturalist, a leaflet for school children. The publisher's address is Lincoln, Massachusetts 01773.

Comstock, A. B. Handbook of Nature Study. 1963. Cornell University Press, Ithaca, New York. An excellent all-around source of information on the life histories of plants and animals. It contains simple facts children like to know, is well illustrated, and provides questions and suggestions about things to look for.

Cornell Science Leaflets are a superb source of information about many science activities. Early leaflets are as valuable as the most recent ones. Write to Building 7, Cornell University, Research Park, Ithaca, New York 14850.

Golden Nature Guides. There are many of these in a useful paperback series. They are well illustrated, inexpensive and easy to use. The ones on trees, wild flowers, insects, reptiles and amphibians, and mammals are especially helpful for primary grades.

Palmer, E. L. Fieldbook of Natural History. 1949. McGraw Hill. 664 pp. of drawings and concise information about rocks, stars, plants and animals. Very useful as a quick reference for essential facts.

GARDENING MAGAZINES AND CATALOGUES

Flower and Garden. Mid-America Publishing Co., 4251 Pennsylvania, Kansas City, Mo. 64111.

Home and Garden. Flower Grower Publishing, Inc., One Park Avenue, New York, New York 10016.

Horticulture. Massachusetts Horticultural Society, 300 Massachusetts Avenue, Boston, Mass. 02115.

George W. Park Seed Co., Inc., Greenwood, South Carolina 29646. Good source for plants, seeds, and equipment such as pots, trays and soil.

Wayside Gardens. Mentor, Ohio 44060. Catalogue with beautiful illustrations and information about growing plants, $1.00.

Garden and nature columns in local newspapers are often good sources for excellent photographs and information of special interest in your own region.

ANIMALS

IDENTIFICATION

AMPHIBIANS

Zim, Herbert S., and Hobart M. Smith, Reptiles and Amphibians. Golden Press, 1956. (3+, Teacher.)

BIRDS

Kieran, John, An Introduction to Birds. Doubleday and Co., 1965. (3+, Teacher.) A guide to common birds.

Wetmore, Alexander, Song and Garden Birds of North America. National Geographic Society, 1964. (Teacher.) Includes records of bird songs.

Zim, Herbert S., and I. N. Gabrielson, Birds. Golden Press, 1961. (3+, Teacher.) Valuable handbook.

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Zim, Herbert S., and Hurst H. Shoemaker, Fishes. Golden Press, 1957. (3+, Teacher.) Well illustrated.

INSECTS

Baranowski, Richard M., Insects. Golden Press, 1964. (Teacher.) Well illustrated, much information.

Demerec and Kaufman, Drosophila Guide. Carnegie Institution, 1967. (Teacher.) Guide to work with fruit flies.

Lutz, Frank E., Field Book of Insects. Putnam, 1948. Includes a list of plant-insect associates.

Parker, Bertha Morris, Six-Legged Neighbors. Row, Peterson and Co., 1961. (K, 1.) Nicely illustrated small book. The children could use it for identification.

Zim, Herbert S., and Clarence Cattam, Insects. Golden Press, 1956. (3+, Teacher.) A small, handy book.

Zim, Herbert S., and R. Mitchell, Butterflies and Moths. Golden Press. (3+, Teacher.) Handbook.

MAMMALS

Zim, Herbert S., and Donald F. Hoffmeister, Mammals - A Guide to Familiar American Species. Golden Press, 1961. (3+, Teacher.) Handbook.

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MOLLUSCS

See Shells, p. 126.

REPTILES

Zim, Herbert S., and Hobart M. Smith, Reptiles and Amphibians. Golden Press, 1956. (3+, Teacher.) Useful handbook.

SPIDERS

Gertsch, Willis J., Spiders and Silk. Audubon Nature Bulletin No. 9, 1966. (Teacher.) Extremely informative.

INFORMATION ABOUT ANIMALS

GENERAL INFORMATION

Blough, Glenn O., Who Lives in this House? Whittlesey House, 1957. (2, 3.) Animals' houses including nests, webs, honeycombs, etc.

Burnett, R. Will, Harvey I. Fisher, and Herbert S. Zim, Zoology. Golden Press, 1958. (3+, Teacher.) Good general reference in handy pocket book. Well illustrated.

Huntington, Harriet E., Let's Go Outdoors. Doubleday, 1939. (K, 1.) Excellent photographs and texts about common garden animals.

AMPHIBIANS

Hogner, Dorothy Childs, Frogs and Polliwogs. Thomas Y. Crowell, 1965. (3+.) Descriptions and life cycles of various kinds of frogs and toads are discussed.

McClung, Robert M., Bufo. Wm. Morrow and Co., 1954. (K, 1, 2, 3.) Life story of a toad.

Miller, Patricia K., and Iran L. Seligman, Big Frogs, Little Frogs. Holt, Rinehart and Winston, 1963. (K, 1, 2, 3.) Simple story of a frog's life history. Charming illustrations.

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Goldin, Augusta, Ducks Don't Get Wet. Thomas Y. Crowell, 1965. (1, 2.) Elementary information about ducks' feathers, the food they eat, how they migrate.

Webb, Addison, Birds in their Homes. Doubleday and Co., 1947. (2, 3.) Good illustrations. Discusses how birds make nests, etc.

Zim, Herbert S., Owls. Wm. Morrow and Co., 1950. (2, 3.) Full of information. Interesting illustrations.

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Farb, Peter, The Story of Butterflies and Other Insects. Harvey House, 1959. (3+.) Much information about behavior. Includes suggestions for collecting and keeping insects.

Hawes, Judy, Bees and Beelines. Thomas Y. Crowell, 1964. (1, 2, 3.) How bees communicate with each other.

Hogner, Dorothy Childs, Grasshoppers and Crickets. Thomas Y. Crowell, 1960. (2, 3.) Beautifully illustrated, lots of information. Includes how to collect and keep crickets.

Hogner, Dorothy Childs, Moths. Thomas Y. Crowell, 1964. (3+.) Well illustrated and interesting.

Kohn, Bernice, Fireflies. Prentice-Hall, 1966. (3+.) Advanced text but interesting lore.

Lane, Ferdinand C., All About the Insect World. Random House, 1954. (3+.) Much information but poor illustrations.

McClung, Robert M., Green Darner. Wm. Morrow and Co., 1956. (K, 1.) About a dragonfly.

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McClung, Robert M., Tiger. Wm. Morrow and Co., 1953. (K, 1.) About a swallowtail butterfly.

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Podendorf, Illa, The True Book of Insects. Children's Press, 1963. (K, 1.) Information about common insects and interesting illustrations.

Shuttlesworth, Dorothy E., The Story of Ants. Doubleday and Co., 1954. (3+.) Advanced, but has many good pictures and much information.

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Hogner, Dorothy Childs, Earthworms. Thomas Y. Crowell, 1953. (1, 2, 3.) Good drawings, much generalized information.

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Selsam, Millicent E., Tony's Birds. Harper and Row, 1961. (K, 1.) Tony is a birdwatcher.

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Morgan, Alfred, Aquarium Book for Boys and Girls. Charles Scribner's Sons, 1959. (3+, Teacher.) How to house and rear aquatic animals.

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Elementary Science Study, Behavior of Mealworms. Education Services, Inc., 1964. (Teacher.) Care of mealworms and experiments with them.

Hussey, Lois, and Catherine Pessino, Collecting Cocoons. Thomas Y. Crowell, 1953. (3+.) Contains much useful information.

Sterling, Dorothy, Caterpillars. Doubleday and Co., 1961. (3+.) Interesting illustrations. Information on collecting and keeping caterpillars.

Stevens, Carla, Catch a Cricket. Young Scott, 1961. (K, 1.) Photographs and text about small boys catching insects.

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Conklin, Gladys, I Caught a Lizard. Holiday House, 1967. (K, 1, 2.) About small wild pets.

WORMS

Hogner, Dorothy Childs, Earthworms. Thomas Y. Crowell, 1953. (1, 2, 3.) Good drawing, much general information.

STORIES ABOUT ANIMALS

Lenski, Lois, Animals for Me. Henry Z. Walck, Inc., n.d. (K.) Includes some non-mammals.

McCloskey, Robert, Make Way for Ducklings. Viking Press, 1941. (K, 1, 2, 3.) A duck family grows up in the center of Boston.

White, E. B., Charlotte's Web. Harper and Row, 1952. (3+.) A story about the life of a spider.

ECOLOGY

Amos, William H., The Life of the Pond. McGraw Hill, 1967. (Teacher.) Excellent photographs, drawings, activities. Includes food cycles and kinds of life at different depths of the pond.

Buchsbaum, Ralph and Mildred Buchsbaum, Basic Ecology. Boxwood Press, 1964. (Teacher.) Small, well-illustrated book, technical but interesting.

Darling, Lois and Louis Darling, A Place in the Sun. Morrow, 1968. (Teacher.) Begins with ecology of a farm; goes on to basic cycles, food chains, man's influence, pollution and conservation.

Farb, Peter, Ecology. Life Nature Library, Time, 1963. (Teacher.) Adaptation and population regulation in many ecosystems.

Hofmann, Melita, A Trip to the Pond. Doubleday, 1966. (3+, Teacher.) Advanced, but beautifully illustrated.

Milne, Lorus and Margery Milne, Because of a Tree. Atheneum, 1963. (3+.) Shows interrelationships of animals and trees. Nice drawings.

Morgan, Ann Haven, The Field Book of Ponds and Streams. Putnam, 1930. (Teacher.) Excellent handbook.

Reid, George K., ed. Herbert Zim, Pond Life. Golden Press, 1967. (Teacher.) Excellent handbook on the characteristics of ponds, details and illustrations of plant and animal life.

Stone, Harris A., The Last Free Bird. Prentice-Hall, 1967. (3+.) Poignant story of a bird that is gradually surrounded by modern civilization. Beautifully illustrated.

FOSSILS

IDENTIFICATION

Fenton, C. L. and M. A., In Prehistoric Seas. Doubleday, 1962. (Teacher.) An excellent reference for ecology and identification of invertebrates.

Zim, Herbert S., and P. R. Shaffer, Fossils, A Guide to Prehistoric Life. Golden Press, 1962. (3+, Teacher.) Fine guide to invertebrate fossils and ways to collect and display them. Convenient for both children and teacher.

INFORMATION

Block, Marie, Dinosaurs. Coward-McCann, 1955. (3+.) Nice sketches, interesting facts. Should excite good readers.

Blough, Glenn O., Discovering Dinosaurs. McGraw Hill, 1960. (2, 3, Teacher.) Relates animals to children's experiences; a well-illustrated and delightful book.

Fenton, C. L., Prehistoric World. John Day Co., 1954. (3+.) Uncolored sketches, materials fascinatingly presented for the advanced third grader.

Ipcar, Dahlov, The Wonderful Egg. Doubleday, 1958. (K, 1, 2.) Delightful story and pictures introduce children to the way dinosaurs looked and how they lived.

May, Julian, They Turned to Stone. Holiday House, 1965. (1, 2, 3.) Fine discussion of non-reptile fossils. Highly recommended.

Neurath, Marie, The Wonder World of Long Ago. Lothrop, Lee, Shepard, 1957. (2, 3.) Presents changes in life of non-reptiles over periods of time.

Ravielli, Anthony, The Rise and Fall of the Dinosaurs. Parents' Magazine Press, 1963. (2, 3.) A ferociously real book, very exciting.

Watson, Jane, The Golden Book of Dinosaurs and other Prehistoric Reptiles. Golden Press, 1960. (K, 1, 2, 3.) A very well-illustrated book that children will find fascinating.

ACTIVITIES WITH FOSSILS

Heller, Robert, ed., Geology and Earth Sciences Sourcebook. Holt, Rinehart and Winston, 1962. (Teacher.) Source of principles, facts, experiments; quick reference.

PLANTS

IDENTIFICATION

Cormack, M. B., The First Book of Trees. Franklin Watts, 1951. (3+.) Very well illustrated.

Podendorf, Illa, The True Book of Trees. Children's Press, 1963. (K, 1.) Chapters on growth, identification, tree flowers.

Podendorf, Illa, The True Book of Weeds and Wild Flowers. Children's Press, 1961. (K, 1.) Simple, informative text. Concerned with the common plants of a child's world.

Sterling, Dorothy, Trees and Their Story. Doubleday and Co., 1953. (3+.) Good photographs but text is dull.

Swain, Su Zan Noguchi, Plants of Woodland and Wayside. Garden City Books, 1958. (3+.) Advanced, but the beautiful illustrations would aid children in identifying many common plants. Includes some lower plants such as algae and lichens.

Watts, May Theilgaard, Flower Finder. Nature Study Guild, Naperville, Ill., 1955. Easy-to-use identification key.

Watts, May Theilgaard, Master Tree Finder. Nature Study Guild, 1963. Pocket-size key to tree identification and information.

Zim, Herbert S., and Alexander C. Martin, Trees. Golden Press, 1956. (3+, Teacher.)

Zim, Herbert S., and Alexander C. Martin, Flowers. Golden Press, 1961. (3+, Teacher.)

Zim, Herbert S., Non-Flowering Plants. Golden Press, 1967. (3+, Teacher.) Valuable handbook.

INFORMATION ABOUT PLANTS

Bancroft, Henrietta, Down Come the Leaves. Thomas Y. Crowell, 1961. (K, 1.) Good drawings of many kinds of leaves.

Blough, Glenn O., Plants Round the Year. Harper and Row, 1962. (1, 2, 3.) Pamphlet with much general information about plants. Nice pictures.

Coe, Geoffrey, The How and Why Wonder Book of Trees. Grosset and Dunlap, 1964. (3+.) Well illustrated, much information.

Dickinson, Alice, The First Book of Plants. Franklin Watts, 1953. (3+.) One of the few books that includes lower plants. Some experiments are suggested. Much general information.

Fenton, Carroll Lane and Herminie B. Kitchen, Plants that Feed Us. J. Day and Co., 1956. (3+.) Good illustrations. An interesting and unusual book on cultivated plants. Would tie in with social studies.

Jordan, Helene J., Seeds By Wind and Water. Thomas Y. Crowell, 1962. (K, 1.) The ecological aspects of plant growth are stressed. Transportation of seeds.

Lane, Ferdinand C., All About the Flowering World. Random House, 1956. (3+.) Attempts to tell us everything, therefore rather general. Includes elementary ecology.

Milne, Lorus and Margery, Plant Life. Prentice Hall, 1959. (Teacher.) Discussion ranges from cellular structure to ecological considerations.

Parker, Bertha Morris, Dependent Plants. Row, Peterson and Co., 1960. (3+.) Includes fungi and parasitic higher plants. Well illustrated.

Parker, Bertha Morris, Flowers, Fruits, Seeds. Row, Peterson and Co., 1941. (3+.) Pamphlet with much general information and nice pictures.

Selsam, Millicent E., Birth of a Forest. Harper and Row, 1964. (3+.) Ecological emphasis — the forest as an environment for all kinds of creatures.

Selsam, Millicent E., The Plants We Eat. Wm. Morrow and Co., 1955. (2, 3.) Interesting material about domesticated plants. Could be used as a basis for experiments or demonstrations.

Sterling, Dorothy, The Story of Mosses, Ferns and Mushrooms. Doubleday and Co., 1955. (3+.) A comprehensive book about lower plants. Profuse and interesting photographs.

Udry, Janice, A Tree is Nice. Harper and Bros., 1956. (K.) Ecological emphasis.

Webber, Irma E., Thanks to Trees — The Story of Their Use and Conservation. E. M. Hale and Co., 1961. (1, 2, 3.) Discusses uses of trees, their relation to the environment and conservation.

Webber, Irma E., Up Above and Down Below. Scott, 1943. (K.) Shows plant structure above and below ground.

Zim, Herbert S., What's Inside of Plants? Wm. Morrow and Co., 1952. (K, 1.) Unique material on plant structure. Good drawings.

ACTIVITIES WITH PLANTS

Baker, Sam Sinclair, The Indoor and Outdoor Grow-It Book. Random House, 1966. (2, 3.) Well-illustrated experiments.

Jordan, Helene J., How a Seed Grows. Thomas Y. Crowell, 1960. (K, 1.) Includes instructions for very simple experiments, planting, and observing growth changes.

Klein, Richard M. and Deanna T. Kline, Discovering Plants. Natural History Press, 1968. (Teacher.)

Many interesting experiments suitable for class or individual students.

Kurtz, Edwin B., Jr., and Chris Allen, Adventures in Living Plants. University of Arizona Press, 1965. (3+.) Good combination of science fiction and scientific information with experiments.

Podendorf, Illa, The True Book of Plant Experiments. Children's Press, 1961. (K, 1.) Simple experiments with growing seeds.

Selsam, Millicent E., Plants that Move. Wm. Morrow and Co., 1962. (2, 3.) Discusses leaves, flowers, fruits, vines and twining plants. Experiment-oriented.

Selsam, Millicent E., Play with Plants. Wm. Morrow and Co., 1949. (2, 3.) Elementary experiments.

Selsam, Millicent E., Play with Seeds. Wm. Morrow and Co., 1957. (3+.) Experiments with seeds.

Webber, Irma E., Travellers All. Wm. R. Scott and Co., 1944. (K, 1, 2.) How seeds are carried.

STORIES ABOUT PLANTS

Selsam, Millicent E., Seeds and More Seeds. Harper and Row, 1959. (K, 1.) A small boy investigates seeds.

Wondriska, William, The Tomato Patch. Holt, Rinehart, 1964. (K, 1, 2.) Enjoyable fantasy with excellent illustrations. Highly recommended.

Zion, Gene, The Plant Sitter. Harper and Row, 1959. (K, 1.) Humorous book about a boy who "sits" plants.

ROCKS AND MINERALS

IDENTIFICATION

Crosby, Phoebe, Jr. Science Book of Rock Collecting. Garrard, 1962. (1, 2, 3.) Beautiful photographs, well-written text opens the world of geology to children. Good specific guide for children's rock collections.

Fenton, C. L., Rocks and their Stories. Doubleday, 1951. (Teacher.) Fine photographs, well-written text will help in specific identification while offering insight into origins.

Shuttlesworth, D., The Story of Rocks. Doubleday, 1963. (K, 1, 2, 3, Teacher.) Splendid colors, good for quick identification. The text is quite mature.

Zim, Herbert S., and P. R. Shaffer, Rocks and Minerals. Golden Press, 1957. (3+, Teacher.) A convenient guide for quick identification of rocks and minerals and brief discussion of origins. Guides in collecting and maintaining rock and mineral collections. Highly recommended.

INFORMATION

Adler, Irving and Ruth, The Earth's Crust. John Day,

1963. (3+, Teacher.) Fine discussion of surface and sub-surface features and processes that make mountains, earthquakes, etc.

Cormack, M. B., The First Book of Stones. Franklin Watts, 1950. (2, 3.) Children should enjoy this presentation despite dull illustrations and advanced vocabulary. Described specimens are well-chosen.

Gans, Roma, The Wonder of Stones. Thomas Y. Crowell, 1963. (1, 2, 3.) A well-illustrated book which presents the origin of the common rock as a matter of great wonder.

Shuttlesworth, D., The Doubleday First Guide to Rocks. Doubleday, 1963. (2, 3.) Valuable information and good drawings make this a highly recommended book.

Syrocki, John, What Is a Rock? Benefic Press, 1961. (1, 2, 3.) With imaginative sketches this book makes a good introduction to a variety of rocks and to processes that build and destroy them.

Zim, Herbert S., What's Inside the Earth? Wm. Morrow and Co., 1953. (2, 3.) Well-presented material, but bland drawings. Elaborations in parallel teacher section.

SHELLS

IDENTIFICATION

Abbott, R. T., ed. Zim, Herbert S., Sea Shells of the World. Golden Press, 1962. (Teacher.) Indispensable guide for quick identification. Also includes geographical distribution.

Bevans, Michael, The Book of Seashells. Doubleday, 1961. (3+, Teacher.) Beautifully illustrated reference book. Handy for children to use.

INFORMATION

Blough, Glenn O., Let's Go to the Seashore. Doubleday, 1941. (2, 3.) Sensitive photography makes what would be a catalogue a lovely book.

Blough, Glenn O., Who Lives at the Seashore? Whittlesey House, 1962. (2, 3.) Imaginative illustrations; ecological approach well handled. Highly recommended.

Dudley, Ruth H., Sea Shells. Crowell, 1953. (3+.) Much information, although few pictures. Highly recommended for the classroom.

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